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THE

PROCEEDINGS

OF THE

LINNEAN SOCIETY

OF

NEW SOUTH WALES

FOR THE YEAR

1938

VOL. LXIII.

WITH TWENTY-TWO PLATES
and 135 Text-figures.

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CORRIGENDA.

(Volume lxiii.)

Page 8, line 13, for *Eriostemon Croweii* read *Eriostemon Crowei*

Page 153, line 14, for *adiantioides* read *adiantoides*

Page 153, line 22, for *Sarchochilus* read *Sarcochilus*

Page 229, explanation of Figs. 1–4 should read

Figs. 1–4.—*Metoligotoma reducta* Davis.—1. Dorsal aspect of well-developed head-capsule, ♂ × 12; 2. Dorsal aspect of ♂ terminalia, × 25; 3. Process of left hemitergite of tenth abdominal segment viewed from above, with extremity raised to same level as base, × 30; 4. Ventral aspect of left cercus-basipodite, ♂, stippling to indicate degree of chitinization, adjacent structures indicated in outline to show relations, × 25.

Page 236, Figs. 31–37, for *ingens*, n. sp. read *ingens* Davis.

Page 251, line 38, for *M. collina*, read *M. collina collina*

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ANNUAL GENERAL MEETING.

WEDNESDAY, 30th MARCH, 1938.

The Sixty-third Annual General Meeting was held in the Society's Rooms, Science House, Gloucester Street, Sydney, on Wednesday, 30th March, 1938.

Mr. E. C. Andrews, B.A., President, in the Chair.

The minutes of the preceding Annual General Meeting (31st March, 1937) were read and confirmed.

PRESIDENTIAL ADDRESS.

For the opening portion of my address I present a short account of some of the Society's activities during the past year.

The concluding part of Volume lxii of the Society's PROCEEDINGS was issued in December. The complete volume (380 plus lxxiv pages, nineteen plates and 217 text-figures) contains thirty papers on a variety of subjects in Natural History and, in addition, a memorial account of Arthur Henry Shakespeare Lucas.

Exchanges from scientific societies and institutions totalled 2,069 for the session compared with 1,795, 1,865 and 2,156 for the three preceding years. During the year two institutions were added to the exchange list, viz.: Natural Science Society, Ljubljana, Yugoslavia, and Tokyo University of Literature and Science.

Since the last Annual Meeting the names of thirteen members have been added to the list, one member has been lost by death and the names of four have been removed on account of arrears of subscription.

Frederick George Hardwick, who died on 4th September, 1937, at the age of 50, had been a member of this Society since 1922. He graduated as Bachelor of Dental Surgery at Sydney in 1909, and later obtained his doctorate from the University of Melbourne; at the time of his death he had been for a few years Lecturer in Dental Materia Medica at the University of Sydney. He was a Vice-President of the New South Wales Branch of the Australian Dental Association. He practised his profession at Lismore for a number of years and then removed to Sydney.

No review of scientific affairs during the past year should omit reference to the irreparable loss world science suffered in the death of Lord Rutherford. I should also refer to the deaths of Sir David Orme Masson and Professor Walter Howchin who, though not members of this Society, had been prominent Australian figures in Science for many years.

The portrait of the late Sir Edgeworth David, referred to in last year's presidential address, was unveiled in the Hall of Science House on 29th September, 1937, by Lady David.

The proclamation protecting certain wild flowers was extended by the Governor-in-Council for a further period of one year from 1st July, 1937.

The vacancies in the Council resulting from the death of Mr. W. W. Froggatt and the resignation of Professor T. G. B. Osborn were filled by the election of Messrs. F. H. Taylor, F.R.E.S., F.Z.S., and A. R. Woodhill, B.Sc.Agr.

We offer our congratulations to Professor T. G. B. Osborn who left Australia in August last on his appointment as Sherardian Professor of Botany at the University of Oxford. We also extend a hearty welcome to Professor Eric Ashby, who succeeds Professor Osborn as Professor of Botany at the University of Sydney, and wish him every happiness and success amongst us. We take this opportunity of expressing our congratulations to Dr. W. L. Waterhouse on his appointment to a Readership in the Faculty of Agriculture in the University of Sydney.

During the year your Council has been active in a number of matters of general concern to those interested in Natural History. It was represented at a conference in respect of the preservation and protection of the native fauna held in Sydney last September, at which there were present representatives from the various Australian States. The report of this conference is available in the Society's library. The Society was also represented at a meeting called by the Royal Zoological Society of New South Wales to consider the desirability of the formation of a faunal reserve for the preservation and breeding of native animals; and your Council lent its support to the protests made by Natural History Societies against the importation into Australia of Californian quail.

The Honorary Treasurer will tell you later that, despite the fact that all efforts to dispose of Macleay House, 16 College Street, at a satisfactory figure have been unsuccessful, the Society's finances have now reached the stage where the annual receipts almost balance the expenditure. That this is possible is due to the provision in Sir William Macleay's will regarding the bequest for Linnean Macleay Fellowships that "the interest on the endowment over and above four hundred pounds a year for each Fellow shall be taken for the general use of the said Society at the discretion of the Council". Sir William's intention is made quite clear, viz., that he desired £1,600 a year to be assured for the salaries of four Fellows and that any further benefit resulting from addition to the Capital of the Fund should be for the Society.

During the year the Council made representations to the Minister for Education asking for the restoration of the Government grant to its pre-depression basis and for an additional grant to make it possible to deal with the accumulation of papers submitted for publication. So far the Government has agreed to restore the annual grant during the current financial year, and I take this opportunity of expressing our grateful thanks for the favourable consideration of this request.

The year's work of the Society's research staff may be summarized thus:

Mr. H. L. Jensen, Macleay Bacteriologist to the Society, extended his work on nitrogen-fixing bacteria. His examination of seventy-seven soils showed *Azotobacter* to be present in only twenty-seven and then in most cases only sporadically. Periodical examination of a soil rich in *Azotobacter* showed that in the immediate neighbourhood of the roots of wheat plants *Azotobacter* is only slightly more abundant than in the soil itself, and it seems that the organic secretions of the wheat plants do not play a significant rôle in nitrogen fixation.

Previous experiments with addition of straw to various soils having given negative results in regard to nitrogen fixation, further control experiments were carried out in which straw was added to pure sand or sand-kaolin mixtures plus lime and mineral nutrients. From these it seems justifiable to conclude that only under partially anaerobic conditions is the straw decomposed with the formation of soluble organic by-products in quantities sufficient to enable the nitrogen-fixing bacteria to display a significant activity. A striking feature of all the experiments is that in all cases where nitrogen-fixation took place, *Azotobacter* were present

in numbers of a much higher order than ever found in soils under natural conditions.

The conclusion also seems justified that, even if the straw is not burned and if the conditions for nitrogen-fixation are favourable, this process could not be expected to cover more than one-fourth to one-third of the nitrogen requirements of the wheat crop—and even this may be a somewhat optimistic estimate, particularly where the yield of grain is high.

The nitrification experiments with wheat-soils have been extended to comprise fifty-five soils; all these soils have been found capable of producing nitrate from their store of humus-nitrogen when placed under conditions corresponding to those of bare-fallowing, but no gain of total nitrogen takes place under these conditions. The practice of alternate cereal-cultivation and fallowing must therefore be expected inevitably to lead to eventual nitrogen-depletion of the soil, unless the use of nitrogenous fertilizers or rational cultivation of leguminous crops is resorted to.

Miss Elizabeth Pope, Linnean Macleay Fellow of the Society in Zoology, continued her work on the morphology of *Heterodontus portusjacksoni*. A paper on the nervous system and associated sense organs is now nearly complete and one on the alimentary canal and general introduction is in course of preparation. Work on the blood vascular system has been rechecked and is in a position to be prepared for publication. Dissections of other systems have also been carried out. Numerous visits were paid to the area at Long Reef, which is being studied, and a record of visits and variations has been kept. The area proved disappointing in one respect, in that it was too flat to show the definite, distinct zones usually associated with a rocky shore. The species, however, are very numerous and new forms are constantly being added to the list already recorded. During the coming year Miss Pope proposes to finish the work on the Port Jackson Shark and to complete some studies on Tiger Flathead anatomy. Ecological work at Long Reef will also be continued.

Mr. Consett Davis, Linnean Macleay Fellow of the Society in Zoology, has continued his work on the Order Embioptera, and has completed one paper dealing with taxonomic and distributional problems. In this paper the distribution of the genus *Metoligotoma* on the New South Wales coast and coastal islands has been correlated with data on former low sea-levels, and the path of the genus has also been traced in islands of the Furneaux Group, in Bass Strait, and in Tasmania, thus giving additional evidence to former hypotheses on the Bassian Isthmus. The problem of convergence in the Order has also been examined. In other papers on the Order in the course of preparation, Mr. Davis has worked on the internal anatomy and bionomics, and has developed a biometrical method for the estimation of the number of instars, the length and seasonal correlation of the life-cycle, and the larval death-rate. Further work on the terrestrial ecology of the Five Islands has also been carried out, the major part of the field records for the introductory paper having been completed. During the coming year Mr. Davis proposes to carry out further work on the Embioptera, particularly on the anatomy and bionomics, and on the ecology of the Five Islands.

Mr. A. H. Voisey, Linnean Macleay Fellow of the Society in Geology, first visited Tasmania and examined a number of occurrences of rocks of Upper Palaeozoic Age. As a result of his investigations he has revised some of the correlations made by previous workers and has prepared a paper on the Upper Palaeozoic Rocks of Tasmania in which are set out his conclusions and the evidence on which they are based. The greater part of his first year's field work

has been carried out in the area between the Hastings and Manning Rivers in New South Wales, an area which was previously little known geologically. Careful field work and detailed mapping have revealed the presence of a variety of sedimentary rocks of Devonian, Carboniferous, Permian, Triassic and Tertiary age, as well as serpentines, basalt, rhyolite and alkaline trachyte. An area of Triassic rocks containing abundant plant remains has been mapped between Lansdowne and Wauchope; a considerable thickness of tillite of Carboniferous age has been shown to occur; and it has proved possible to separate the limestone belts into two series, one of Carboniferous age and one newer. The serpentines intrude the Carboniferous tillite and it is believed that they also invade beds of the Kamilaroi System. The results of Mr. Voisey's work in this district will appear in a series of papers after he has confirmed a number of his correlations by comparison of the rocks with those further north and north-west in the New England area. During the coming year Mr. Voisey proposes to continue this work in the coastal area of northern New South Wales.

Miss Ilma M. Pidgeon, Linnean Macleay Fellow of the Society in Botany, continued her work on the ecology of the Central Coastal Area of New South Wales, completing two papers, one of which, "The Environment and General Features of the Vegetation", appeared in the PROCEEDINGS for 1937; the other, "Plant Succession on the Hawkesbury Sandstone", will appear in the PROCEEDINGS for 1938. Miss Pidgeon has also carried out a considerable amount of field investigation on the Eucalyptus Forests of the Hawkesbury Sandstone and will finalize this section of the work very shortly. During the coming year she proposes to continue her work on the Eucalyptus forests of the Wianamatta shales of the Central Coast, and to extend her ecological investigations to the western slopes districts.

Seven applications for Linnean Macleay Fellowships were received in response to the Council's invitation of 29th September, 1937. I have pleasure in reminding you that the Council reappointed Miss Elizabeth C. Pope, Mr. Consett Davis, Mr. A. H. Voisey, and Miss Ilma M. Pidgeon to Fellowships in Zoology, Zoology, Geology and Botany respectively for one year from 1st March, 1938. We may wish them all a successful year's research.

SOME MAJOR PROBLEMS IN STRUCTURAL GEOLOGY.

Introductory.—The Structural History of the Continents.—Some Salient Features of Modern Mountains.—Some Salient Features of Ancient Mountains.—Hypotheses of Continental and Oceanic Evolution: Wegener and Others.—The Crust of the Earth.*

Introductory.

The present imposing structure of philosophical geology has been erected, with incredible difficulty, through the correlation of numberless careful records of marine advances and retreats in the past, of sedimentation (both in amount and variation), of folding and uplift, of volcanic and seismic action, of igneous intrusion, of stream and wave erosion, of ancient and modern life forms, and of related matters.

The pioneers of geological science were true spiritual descendants of Antaeus; they maintained unbroken touch with their sources of knowledge and strength, the Earth, and thus they gained insight into terrestrial activities. It is only necessary to mention the names of L. Agassiz, Barrande, de la Beche, de Beaumont, Brongniart, von Buch, Buffon, Chamberlin, Cuvier, Dana, Darwin, Desmarest, Dutton, G. K. Gilbert, Guettard, Hall, Humboldt, Hutton, Lamarck, Lapworth, Lyell, Mallet, Hugh Miller, Murchison, Nicol, Richthofen, de Saussure, Scrope,

Sedgwick, William Smith, Sorby, Giraud-Soulavie, Steno, Suess, and da Vinci to know that "there were giants in those days". Of these, and of many others, it may well be said that "their works do live after them". Through their efforts, and of others like them, the philosophy of to-day leads to the science of to-morrow. Light thus is thrown upon major problems in geology; for example, the development of continents and ocean basins, of mountain ranges, of biological evolution, and the history of past glacial periods.

Philosophical studies, however, even in geology, suffer amazingly from the ever present but alluring metaphysical element. Students, nurtured carefully in the principles of orthodox geology, indulge in speculations which appear not to be sanctioned altogether by the testimony of the rocks. Such flights of fancy, with increasing departure from the Earth, diverge more and more from actual facts of earthly processes. The Wegener Hypothesis, a high-level flight in matters geological, and one of great stimulation in many ways, nevertheless smacks suspiciously of the waxen wings of Icarus and courts a similar fate when leaving the earth too far below. However, by means of its exquisitely poetical presentation, it has made a powerful appeal to the love of the marvellous in man, scientist and non-scientist alike. It captivates the imagination with its semblance to an ancient epic, a veritable Odyssey, in which the continents and the Polar sites, like Homeric or Virgilian heroes, are driven by warring Fates from their grand old home of Pangaea only to wander helplessly, like so much plankton, through the vast waste of Oceanus. Wegener, by this imaginative excursion, was led to infer the impermanence of position of the major structures of the Earth, such as continents and oceans.

Argand, whose field studies in the western Alps amount to genius, and to whom students of geological structure have been placed under an everlasting debt of gratitude, arrives at the conclusion that the external Prealps of the Bernese Oberland represent a small portion of Africa resting upon Europe. The student naturally asks whether all the available evidence had been exhausted before arriving at this conclusion, and whether the confrontation of this idea with the known history of Europe during the pre-Cambrian, Caledonian, and Hercynian activities might not have led to a more simple explanation of the Prealpine occurrences.

Again, in Argand's analysis of the structural history of Asia, the desire in the mind of the reader is to compare his account with the structural history, so far as known, of the individual Asiatic countries from the pre-Cambrian to the present, and especially of those countries through which the former Tethys extended, namely, Asia Minor, Persia, Afghanistan, India, and south-eastern Asia.

When Joly explains the great topographical revolutions as depending, in great measure, on the influence of accumulated radioactive energy in the subsurface regions, the reader naturally asks whether this explanation is the simplest available, in view of the paucity of direct evidence in support of his views.

The student of the Newton and Darwin type seeks a simple explanation of natural phenomena; he knows that there are many ways in which, conceivably, a form such as a mountain range may have been caused, whereas, in reality, it was produced in one way only, namely, that of Nature, and that particular way is the one to be ascertained. He knows, moreover, that the more ingenious and complicated a hypothesis is which seeks to explain earth phenomena, so much the more is it to be suspected. Newton's theory of gravitation explains the movements of the planets more simply than an earlier complicated one invoking the constant attention of special celestial beings; Darwin's theory of natural selection explains

the presence of the varied forms of life on the Earth more simply than the earlier hypotheses of special creations.

To the several points mentioned above a return is made at a later stage of this address, but as a preparatory step it may be helpful to make brief reference both to the structural history of the continents based on the principles of orthodox geology and to a few of the main features of modern and ancient mountains. Following a brief discussion of the hypotheses of Wegener and others, it is proposed to make a simple inference concerning the history of the present continents and oceans from a knowledge of certain well-known facts of geography and geology.

The Structural History of the Continents.

1. *Europe.*—The accompanying notes are based mainly on the published writings of Argand, Bailey, Foumarier, Haug, Heim, Holtedahl, Horne, de Lapparent, Karpinsky, Kober, Lugeon, Mushketov, Neumayr, Peach, Sederholm, Staub, Stille, Suess (father and son), Termier, Törnebohm, and many others. An analysis of their writings leads to the conclusion that the continent of Europe probably has grown in stability rather than in actual area since the pre-Cambrian; that this stability not only has been secured progressively, but that it has originated in part through the formation of mountain systems and the grouping of same around an ancient nucleus; in part also by the welding of this ancient nucleus to still another great growing stable block in western Asia; and by the down-warping of an ancient borderland lying to the north and west of the present land area. The ancient nucleus included Fennosarmatia and its natural western extension, together with the foundation of the basin which includes north Germany, Denmark, Holland, eastern England, and a large portion of both the Baltic and the North Sea areas.

This nucleal continent was separated from Asia by depressions which are now occupied by the Ural and Timan Mountains. Its south-eastern boundaries may have passed through the Caspian and Black Sea areas. The positive element of this nucleus occupies the area of Finland and Sweden in the main, with traces in southern Russia. The negative portion occupies the remainder of the nucleus as outlined above.

The Caledonian movements affected the British Isles, Scandinavia, Spitsbergen, and other areas, with varying degrees of intensity, during the Ordovician, Silurian, and Devonian. In the British Isles the indications are that the folding activities generally were delayed progressively in a north-west to south-east direction. In northern Greenland the folding appears to have been delayed in great measure until the Devonian.

Overfolding and heavy thrusting were in a north-westerly direction mainly in the northern portion of the British Isles, whereas, in the Scandinavian Peninsula the more powerful movements appear to have been directed towards the south-east, that is, towards the Fennosarmatian foreland. The movements were intense also in Spitsbergen. There appears to be no consensus of opinion about the origin and age of the gneisses moved to the north-west and south-east respectively in these thrustings; some observers consider them to be a portion of the ancient foundation, while others tend to regard them, in part at least, as the effect of "intrusion tectonics" among rocks younger than the pre-Cambrian. Whatever their origin, the Caledonian orogeny appears to have brought into being a strip of relative stability round the ancient nucleus on its more northern aspect, the movement producing an earth undulation from which thrustings took place outwards from the main axial trend.

The next important stable addition to the growing continent was made by Hercynian activities which extended through the Carboniferous and Permian periods. Broad zones of stable lands thus were firmly attached to, or welded on to, the eastern, southern, and western portions of the ancient nucleus. In the east, this resulted in the close knitting together of the Russian and western Siberian blocks, while in the south-east, the action is visible in the Donetz region. Our knowledge, however, is incomplete for this area by reason of the cover of younger sedimentaries in the Russian Platform; nevertheless, the evidence does not suggest that the movement here was so powerful as it was in the west of Europe where a very broad zone of stable land was formed, including Silesia, Bohemia, Germany as far north as Berlin and the Ruhr, Belgium, France and Spain in great part, together with England and Ireland as far north approximately as the latitude of London.

The sediments of this wide area were closely folded and overthrust, these movements being associated with the phenomenon of "intrusion tectonics" referred to later in the chapter on Ancient Mountains. The thrusting, so far as it has been observed, appears to have been towards the north in the main, but the southern boundary of the broad zone affected by these Hercynian activities has been obliterated in great measure by later Alpine movements. It is highly probable that, like the Caledonian and Alpine movements, there was overfolding and thrusting to the south during the Hercynian movement. The Caledonian and Hercynian zones osculate, or overlap, in the western portion of the British Isles.

By the close of the Palaeozoic, therefore, Europe had been attached firmly to western Asia, and, moreover, it had developed broad zones of stability round the northern, western, and southern sides of the ancient nucleus. A study of the existing trend lines of the Hercynides in France, Spain, and the British Isles suggests that they form closed curves in the Atlantic, bending back on themselves thence towards Europe, a considerable portion of the continent as it then existed having disappeared into the eastern Atlantic.

The Alpine movement added greatly to the stability of Europe, especially in the area lying south of the Hercynian fold zone. A complex geosynclinal area, with a long history of instability, had extended throughout southern Europe from the Atlantic to the eastern Caucasus. This region, from the middle Mesozoic onward, had been subject to movements of undulatory elevation with overthrusting directed toward the northern foreland represented by the worn-down Hercynian mountains. Thrustings to the south also were prominent. This complex activity reached a maximum in the middle Oligocene, and was revived as a great undulatory uplift at the close of the Tertiary. The present forms of the Pyrenees, the Sierra Nevada (Spain), the Alps, the Apennines, Carpathians, Dinarides, Balkan, and Caucasian ranges were determined by this closing and post Tertiary uplift; their appearance during the Oligocene, Eocene, and Cretaceous revolutions remains merely a matter of conjecture.

By these three great complex movements, namely, the Caledonian, Hercynian, and Alpine foldings, the present grand physical stability of Europe has been secured progressively, although very gradually, during the time which has elapsed since the dawn of the upper pre-Cambrian.

2. *Asia.*—The accompanying note on the structure of Asia and its island arcs is based mainly on the writings of Ahnert, Barbour, Berkey, Blackwelder, de Böckh, Brouwer, Teilhard de Chardin, Grabau, Hayden, Hobbs, Huntington,

Kanehara, Koto, Lake, Middlemiss, Molengraaf, Morris, Mushketov (father and son), Obruchew, Richthofen, Suess, Ting, Verbeeck, Wadia, Willis, Wong, Yabe, and Zwierzycki.

Asia consists of various large and ancient nuclei which have become knitted or welded together during Palaeozoic, Mesozoic, and Tertiary time. These foundation blocks are partly positive and partly negative in form. Among the positive elements may be mentioned the Siberian massif proper, the Chinese massif proper, the massif of south-western China, of Peninsular India, of Arabia, and fragments which remain of the old borderland Cathaysia. Among the more important negative elements possessing ancient pre-Cambrian basements may be mentioned Thibet, Ordos, the Chinese basin proper (Szechuan), the Tarim block or Serindia of Argand, the Burmah and Siam basins, the Gobi Desert, the Sistan and Iran basins (Persia).

The Caledonian movements elevated the extensive region lying between the Lena and Yenisei Rivers, and girdled that region with a grand and compound system of mountain ranges, on its eastern, southern, and western sides. The site of these mountain systems had been occupied previously, for a lengthy period, by a long curved marine trough, which had received heavy sedimentation. The contained sediments then had been closely folded and overthrust, culminating in the formation of high mountains.

By the beginning of Devonian time, this portion of Asia, known as Angara Land, with its surrounding ranges, had been stabilized, and it has remained so ever since.

By middle Devonian time, this stable block, together with its compound mountainous border, was almost surrounded, except on the north, by a geosyncline which had arisen as a compensatory mechanism to the uplift of the Caledonian mountains surrounding Angara Land. This long arcuate sea-way was connected indirectly with a geosyncline extending from Asia Minor through Persia, the Himalayan region, and south-west China, the connecting waterways passing directly through the Thian Shan and Ferghana regions. Extensions also of the Tethyan waterways completed the marine investment of the vast Thibetan block by way of the Kuen Lun and Nan Shan regions.

Then followed the important and widespread Hercynian movement, which brought into being the Ural, Thian Shan, Altai, Kuen Lun, Nan Shan, and western Tsing Ling mountain systems. All these grand topographic features had been born of the closely folded and intruded sediments of the Palaeozoic geosyncline.

Asia thus at the close of the Palaeozoic had become a stable geological structure over the area extending eastward from the Ural to a point beyond Peiping, and southwards as far as Lat. 40° N. Europe and Asia thus, north of Lat. 40° N., were firmly joined together at this stage, and it is evident that the growth of Asiatic stability was proceeding southwards progressively towards the ancient land of Arabia, Peninsular India, and south-eastern Asia, while at the same time this stability was moving also steadily eastwards towards the Pacific Ocean.

During the Jurassic and Cretaceous, a great stable addition was made to the continent in the direction of the Pacific by the growth of the Yenshan, Cathaysian, and Verkhoyansk mountain systems within former geosynclinal areas of long standing.

Turning now to the more southern portion of the continent, it may be noted that the geosynclines of Tethys were outlined prior to the Cambrian, and that marine conditions obtained in them in greater or lesser degree during the whole

of the sedimentary record from the Cambrian to the close of the Nummulitic period. Palaeozoic, Mesozoic, and Eocene marine sediments occur in them in such relation as to suggest conformable deposition from the Cambrian to the Upper Carboniferous, and from the Permian (inclusive) to the close of the Mesozoic. An unconformity appears to separate the Carboniferous and Permian sedimentation. During the closing Cretaceous, and especially during the Tertiary, the Himalayan and related mountain systems were born. During this period also the Nanling, Sakhalin, Sikhota Alin, and Anadyr mountain systems arose on the Pacific side; and as the Himalayan and related Tethyan systems extended the area of stable land southward, so the eastern systems extended the stability farther towards the Pacific.

The modern mountain systems of Asia, which attain their grandest development in the Himalaya, the Kuen Lun, Nan Shan, Thian Shan, Alai, Trans Alai, and Elburz groups, together with the Pamirs and the Thibetan plateaus, are the result of undulatory uplifts, or revivals of uplift, in closing and post Tertiary time, of the earlier Asiatic, Palaeozoic, Mesozoic, and Tertiary fold mountains.

The structural history of Japan, Formosa, the East Indies, and the associated Asiatic insular groups, is not confined to the undulatory uplift which they experienced during late and post Tertiary time. On the contrary, each has had a long structural history, that of Japan and Borneo, according to some authorities, being traceable to pre-Cambrian time. So also for some of the other large islands. All authorities are in agreement as to the evidence of Palaeozoic, probably lower Palaeozoic, activities in the larger island areas.

3. *North America.*—The notes on North America are based mainly on the writings of Barrell, Blackwelder, Chamberlin (father and son), Daly, Dana, Davis, Dawson, Diller, Dutton, Gilbert, Gregory, James Hall, Iddings, Keith, Lawson, Lindgren, Logan, Longwell, Moore, Moss, Powell, the Rogers Brothers, Ruedemann, Salisbury, Schuchert, Ulrich, Vaughan, Walcott, and Willis.

The tectonic history of North America appears to be bound up with the growth of several very extensive areas of early pre-Cambrian rocks, and the subsequent welding together of these during Palaeozoic and later time.

Of these ancient massifs, the chief appears to have been the Canadian Shield (inclusive probably of Greenland and the islands north of Canada), and its natural but concealed extensions to the south and west. A second may be traced in Colorado, Utah, Arizona, New Mexico, and California; a third appears to have formed a borderland, remnants of which may be traced on the Atlantic side, trending sympathetically with the Appalachian region; on the Gulf side they lie subparallel to the folded mountain systems of Texas, Oklahoma, Arkansas, and neighbouring areas. An ancient borderland appears also to have existed on the Pacific side.

Of the positive elements, the Canadian Shield is the grand outstanding example. In places it is covered with subhorizontal or gently undulating sediments of late pre-Cambrian and Palaeozoic age.

A considerable portion of the ancient stable area is negative in form, much of it being depressed below sea-level and covered with moderate thicknesses of subhorizontal or gently folded Palaeozoic and later sediments. This, the Central Stable Region of Schuchert, finds its European homologue in the Russian Platform, the north German plain, and the lowlands to the west, together with the Baltic and North Sea areas. Between the large stable nuclei and the borderlands there existed an irregular and compound but connected zone of structural depressions

occupied by geosynclines. Chamberlin[1] draws attention to the apparent growth in stability of the ancient nuclei themselves by marginal additions of closely folded zones of sediments deposited in geosynclines.

Neglecting for the present purpose the Palaeozoic geosynclinal conditions recorded for the north of Greenland and certain islands north of Canada, which, however, fit well into the general scheme, it may be inferred that the main geosynclines of the continent are the Appalachian with a western but indirect extension through the Missouri, Arkansas, Oklahoma, and Texas regions, and the Cordilleran geosyncline extending from Texas northwards through the present Cordilleran region to the Arctic. A structural depression, related to the two main geosynclines mentioned above, appears to have encircled the Colorado Plateau block.

The process of welding together these ancient lands began on the Atlantic side and advanced subsequently towards the Pacific by way of the Gulf region. It was not so much an actual increase of area that the continent experienced with the passage of time as a definite increase in stability. American geologists generally, following Walcott, appear to consider that the continent actually was larger in late pre-Cambrian time, and probably during various later stages, than it is to-day.

The first definitely successful efforts at the welding process appear to have taken place during the Caledonian movements. The earliest record of this is in the lower Ordovician, at which time folding of sediments is recorded from New England, Tennessee, and Alabama, all within the Appalachian depression. A younger movement of folding, during the late or closing Ordovician,[2] is recorded from eastern Canada, Maine, New Jersey, and New York. This action also took place in the Appalachian tract.

A still more important movement of close folding occurred during the later Devonian when the northern portion of the Appalachian way was welded on to the ancient foreland. This movement affected New England and various portions of Canada, including the Gaspé Peninsula. Plutonic intrusions accompanied the folding.

The Hercynian folding affected the geosynclinal tract of the Gulf region, together with the Appalachian geosyncline south of New England. It was a powerful and compound movement, being especially effective towards the close of the Lower Carboniferous, the late Upper Carboniferous, and towards the close of the Permian. Close folding and marked thrusting were common at the same time, being directed primarily towards the ancient nucleus. Plutonic intrusions on a grand scale gave rise in places, apparently, to "intrusion tectonics" phenomena.

Thus, by the close of the Palaeozoic, the continent, as far west as the Cordilleran geosyncline, had gained markedly in stability gradually but progressively from north to south and from east to south-west.

Close folding movements subsequently passed westwards towards the Pacific; two grand examples are recorded from the Cordilleran area during the Mesozoic. The Cordilleran geosyncline itself has had a long and complex history. In its central portion, marine sedimentation formed a practically conformable series from the upper pre-Cambrian to the closing Jurassic, and, in its eastern portion,

[1] Chamberlin, R. T., "Significance of the Framework of the Continents", *Jour. Geol.*, xxxii, 1924, 553-555; "Shifting Orogenic Belts of the Southern Canadian Shield", *Jour. Geol.*, xlv, 1937, 663-681.

[2] See, however, Keith, A., "Taconic Revolution . . . Quebec", *Bull. Geol. Soc. Amer.*, Abstracts, 1937, p. 28.

even to the close of the Cretaceous. The gradual growth of a central geanticline during the Triassic and Jurassic divided the old, wide, Cordilleran seaway into two portions, an eastern, or Rocky Mountain, and a western, or Pacific, sequent trough. Close folding and thrusting towards the ancient nuclei, at the close of both the Jurassic and the Cretaceous, stabilized the continent, except in the Pacific region where close folding and overthrusting have persisted at various stages during the Tertiary and to the present time.

One significant feature in this growth of stability in the Cordilleran area was the girdling of the great negative mass of the Colorado Plateau region with folded mountain systems belonging in part to the close of the Jurassic and in part to the close of the Cretaceous.

The present grand mountain systems of the continent were formed in stages by variable undulatory uplifts during closing and post Tertiary time. The old borderlands appear to have been downwarped in great measure as movements compensatory to the positive mountain growths.

In this continent then, as in Asia, may be noted the progressive growth of stability towards the Pacific, and the welding of ancient nuclei by marginal additions. North America, however, like South America, is a somewhat more simple structural unity than Asia.

4. *Australia.*—The structural history of Australia is bound up with that of the outlying island arcs, the chief members of which include New Guinea, New Britain, New Ireland, the Solomons, the New Hebrides, Fiji, New Caledonia, New Zealand, and Macquarie Island. These island groups appear to bear structural relations to the mainland of Australia, similar to those which the Japanese and other insular arcs bear to the mainland of Asia, and which the North American Cordillera and the Andes bear to the main block of North and South America respectively.

The Palaeozoic history of the Australian mainland itself has been considered briefly in a recent publication.[3] The present marked stability of Australia proper has been secured by the knitting together of several ancient nuclei into one massive unity during the Palaeozoic, whereas the outlying insular arcs have persistently retained their mobile and unstable structures.

The ancient nuclei of the mainland are composed fundamentally of early pre-Cambrian structures which are partly positive and partly negative. The positive elements are covered in no small measure by subhorizontal to gently undulating sediments of upper pre-Cambrian, Palaeozoic, and post-Palaeozoic age.

The main positive elements of the nuclei include Yilgarnia or south-western Australia, Stuartiana in northern Australia, Carpentaria in north-eastern Queensland, and Willyama or the Greater Broken Hill district. The main negative portion is known as the Great Australian Artesian Basin, approximately seven hundred thousand square miles in area. It is proposed to name this the Queensland Platform. In addition to these nuclei a long borderland appears to have extended, with a possible break in the Newcastle–Sydney district, from the north of Queensland to a point well south of Tasmania. The nuclei and the eastern borderland (or borderlands) were separated from each other by long geosynclines, the eastern troughs receiving sediments from the eastern borderland, while the

[3] Andrews, E. C., "The Structural History of Australia during the Palaeozoic", *Jour. Roy. Soc. N. S. Wales*, 1937, pp. 118-187. (In this publication the list of reports dealing with the Structural History of the Continent on page 119 should have included the Presidential Address of L. A. Cotton on the pre-Cambrian of Australia: *Jour. Roy. Soc. N.S.W.*, 64, 1930, p. 50.)

central troughs were fed from the geanticlines of Willyama and of the southern margin of the northern nucleus (Stuartiana). The great south-western block (Yilgarnia) appears to have functioned as a foreland even during the later stages of pre-Cambrian time.

The growth of the continent in stability was a slow and gradual process; it proceeded first as from west to east and thence north-easterly during the Caledonian movement, thus knitting together the masses of Yilgarnia, Stuartiana, Willyama, and the Queensland Platform. By the powerful folding movements which closed the upper Ordovician and the upper Silurian the continental mass lying to the west of the meridian of Melbourne had been rendered stable; Tasmania had been attached firmly also to the growing continent at the close of the Silurian (its insular position to-day is due to the recent slight rise of the sea-level, the deepest portion of the shelf connecting Tasmania with the mainland being less than two hundred feet).

At the close of the mid-Devonian the eastern portion of Victoria and the extreme south-eastern portion of New South Wales had been added to the area of structural stability, and at the close of the Devonian, the remainder of New South Wales, with the important exception of New England and the neighbouring areas in the north-east of the State, had become part and parcel of the stable continental mass which was now consolidating itself in a general easterly direction, that is, towards the Pacific. The consolidation of the coastal strip north of Lat. 33°S. (to Lat. 11°S.) was reserved for Hercynian activities which osculated the stable Caledonian mass apparently about Lat. 33°S.

The main Hercynian movements so far as they have been detected to date, appear to have occurred during the lower Carboniferous and at the close of the Permian. They were movements of close folding in places, especially those of closing Permian time, with overthrusting towards the ancient nucleus. The continent appears to have remained as a stable structural unity since the Palaeozoic, save for a local movement of folding of mild nature which affected a strip of coastal area to the north of Brisbane and for a warping action which submerged the greater portion of the ancient eastern borderlands (Corallia, Tasmantis, Euronotia) in Tertiary and post-Tertiary time, apparently as a compensatory movement to the undulatory uplift of the eastern Australian highland.

The outlying island arcs, although quite mobile and unstable structures today, have had long and complicated structural histories, as shown by Bartrum, Benson, C. A. Cotton, Hector, Henderson, Hutton, King, McKay, Marshall, Morgan, Park, Speight, and the staff of the Geological Survey of New Zealand. New Zealand contains sediments belonging to the earliest Ordovician, and associated with these are altered sediments which may be pre-Ordovician. Close folding movements are recorded for New Zealand during both the late Palaeozoic and the Mesozoic (closing Jurassic or early Cretaceous). Great undulatory uplifts, associated with folding and crushing of massive land blocks, occurred during the Tertiary and post-Tertiary. New Guinea contains fossiliferous Devonian sediments associated with crystalline rocks which appear definitely to be of much greater age. This vast area has suffered also from close folding and overthrusting during Tertiary and post-Tertiary time. New Caledonia, Fiji, and some other important island groups of the Australasian arcs have had structural histories also of long duration.

The outstanding difference between Australia and its related island arcs, lying to the east and north, resides in the marked structural stability of the mainland and the equally pronounced instability of the island arcs, particularly those

lying north of New Zealand and west of Fiji. For a brief discussion of the structure of the insular arcs reference may be made to a paper by Benson.[4]

5. *South America.*—The notes on this region are based, mainly, on published reports by Berry, de Böckh, Bowman, Branner, R. T. Chamberlin, Douglas, Evans, H. E. Gregory, Singewald, Schuchert, and Steinmann.

The structural history of South America, similarly to that of North America, appears to be bound up with the knitting together of several ancient structures occurring as nuclei and elongate borderlands, the greater portion of the latter being now submerged by the ocean apparently in compensation for the undulatory rise of the present Andean mountain systems and the broad plateaus in the east.

The main nucleal elements include a very large portion of Brazil, together with a portion of the Argentine, and the ancient shield north of the Amazon. These, generally, are positive elements, but their continuations to the west and south are negative structures whose ancient surfaces are now concealed beneath a vast cover of younger rocks. Traces of the ancient borderland are still to be seen along the eastern coastal area of Brazil and throughout the western coastal area of the continent.

Mobile depressed areas or geosynclines once separated the ancient shields and borderlands, and it was the close folding of the sediments accumulated therein during the Palaeozoic and later time which completed the stabilization of the continental structure.

To Schuchert we are indebted for the recognition of the structural history of the Franciscan Geosyncline in eastern Brazil. As in eastern North America, where the Appalachian tract had been rendered stable by Palaeozoic foldings, so also the long enduring Palaeozoic history of sedimentation in the Franciscan trough appears to have been ended by a powerful movement at the close of the Palaeozoic.

The tectonic history of the Andean and Venezuelan areas reveals many points of similarity with that of the Cordilleran region of North America, allowance being made for our general lack of definite knowledge concerning South American geology.

The geosynclinal areas of the Andean and Venezuelan regions have had a long and complicated history. Each of the main Palaeozoic time divisions is represented, at least in part, either by marine or terrestrial sediments.

Until recently it was thought that the earlier Palaeozoic sediments in the great Andean trough occurred only between Lat. 30° and 10°S., but de Böckh and others have found a lower Palaeozoic sequence in Colombia. Both Caledonian and Hercynian mountain-making activities have been recorded within the Andean area, but the most powerful movements detected to date occurred during the closing Cretaceous and the Tertiary periods. Again, although certain observers doubted the existence in the Andes of close folding with the accompaniment of powerful thrustings and nappe structures, nevertheless de Böckh has shown, in Colombia, that not only did folding occur after the Upper Carboniferous, but that very powerful folding movements occurred in the eastern Cordillera towards the close of the Cretaceous, with crystalline rocks thrust over the Cretaceous.[5] These were Laramide movements in which Alpine structures occur. Similar

[4] Benson, W. N., "The Structural Features of the Margin of Australasia", *Trans. N.Z. Inst.*, 55, 1924, 99-137.

[5] de Böckh, H., Lees, G. M., and Richardson, H. D. S., "Stratigraphy and Tectonics of the Iranian Ranges". In "Structure of Asia", 1928, pp. 164-167. Methuen.

heavy thrustings occur also in Venezuela, and in each case the thrustings are recorded to be towards the ancient nucleus.

In the Andean region proper, Tertiary folding was intense and igneous displays, both intrusive and extrusive, occurred on a grand scale. At the close of the Tertiary, and possibly even later in part, the Andean areas were uplifted in the form of complex earth undulations to their present positions.

As in the examples of Asia, Australia, and North America, the growth of stability has been gradually, but progressively, toward the Pacific and toward the subequatorial mobile hinge areas.

6. *Africa.*—The notes on Africa are based on reports by Chamberlin, Daly, Du Toit, J. W. Gregory, Hume, Krenkel, Monod, Rogers, and Schuchert.

The structural history of this huge area (approximately twelve million square miles) reveals it as an ancient massif of marked stability, around whose north-western and southern extremities chains of folded mountains have grown during Palaeozoic and later time. Africa differs materially from the continents above described in that it is mainly an ancient nucleus, partly positive and partly negative in form, but of such stability that pre-Cambrian rocks of various ages occur in the form of great basins, composed of gently dipping sediments which rest in turn upon an ancient but coextensive foundation. Other huge basins occur also, in which the ancient rock structures are covered with gently dipping or undulating beds of Palaeozoic and of Mesozoic age.

Interest attaches to the folded sediments of the extreme north-western and southern areas. Those of the north-west range in age from the Lower Palaeozoic to Recent. After a long and varied structural history, the geosynclinal sediments of the Atlas region were subjected to Alpine movements during Tertiary time. The present magnificence of the Atlas Mountains appears to be the result of a compound undulatory movement at the close of the Tertiary. There is evidence of a possible pre-Palaeozoic (certainly pre-Devonian) folding of geosynclinal sediments in the extreme south of the continent where the trend of the great folds follows the arcuate coastal sweep of the continent. After the deposition of a very thick series of Palaeozoic and early Triassic sediments, in a trough disposed subparallel to the main direction of the present coastal area, a powerful movement of folding occurred, whose general trend followed that of the earlier folding. Thrusting towards the northern foreland is recorded. There is thus in the south a marked parallelism existing between both the pre-Devonian and the early Mesozoic foldings on the one hand, and the southern coastal trend on the other. The great undulating and rifted plateaus of Africa appear to be referable to closing Tertiary activities.

7. *Antarctica.*—The geological information concerning this extensive area is meagre in the extreme. Exploration, however, has revealed enough to suggest that it consists mainly of a positive area of ancient rock structures in the form of a gigantic broken plateau or shield supporting an ice cap of unknown but great thickness. Former important synclinal conditions are indicated for the area occupied by Graham Land and its arcuate extensions and associates; close folding of the sediments deposited therein appears to have occurred in Tertiary time, or, in other words, this marginal area of Antarctica may be regarded tentatively as a southern extension of Andean or eastern Pacific structures.

In the Ross Sea area, the old erstwhile negative block has been raised, together with its subhorizontal capping of Palaeozoic sediments, to heights of many thousands of feet above sea-level in very late geological time.

Some Salient Features of Modern Mountains.

The general arrangement, together with the nature, of modern mountain ranges, has been discussed by the writer elsewhere.[6] In the present note, attention is confined to their more important forms.

Chamberlin has considered[7] the peculiar location and arrangement of mountain ranges generally. "If we turn", he says, "to the maps, we see how, generally, the world over, the present and ancient mountain chains have paralleled the borders of the present continents. This is not a new observation, for it has been stated many times before by various writers, but the wide prevalence of this relationship, and particularly its seeming fundamental importance, have been so generally overlooked or lightly brushed aside in favour of a great variety of other interpretations, based, it seems to the writer, on slight evidence, real or fancied, that it ought to be brought sharply to the front and emphasized."

The writer's observations are in general agreement with those of Chamberlin. His statement might be amplified, however, to the extent of classifying modern mountain systems as revivals, by undulatory uplift in the main, of areas of folding, ranging in age from upper pre-Cambrian to closing Tertiary. Exceptions to this generalization are considered later.

Around the ancient nuclei, including both the positive and negative forms, mountain ranges have been formed by close folding of sediments deposited in geosynclines. These foldings have taken place at various periods during Palaeozoic, Mesozoic, and Tertiary time. Relative stability followed on close folding and on the associated igneous intrusions within the former unstable areas, and thus the sites of subsequent foldings tend to recede from the positions occupied by the earlier folded mountain systems. Despite the relative stability gained thus, however, it is significant that practically every mountain system formed since the dawn of the upper portion of pre-Cambrian time has been revived by undulatory uplift in very late geological time to form the imposing features presented by modern mountain systems.

The main mountain systems of the world are those enumerated by Chamberlin, namely, the Cordillera of west and north America, the Andean chains with their southern and eastern (Venezuelan) extensions, the Tethyan ranges of southern Europe and Asia, the insular arcs of Asia and Australasia, the East and West Indies, the Atlas of Africa, and so on. These, in great measure, represent revived uplifts of sediments folded during the Tertiary.

If consideration, however, be given to the mountain chains of the more central portions of Asia, it will be noted that they also are forms of the first magnitude. Mention need be made only of the Kuen Lun, Nan Shan, Alai, Trans Alai, Thian Shan, Altai, and Sayan systems. Certain peaks in the Kuen Lun, Sarikol, Nan Shan, Thian Shan, Trans Alai, and a few other systems, far exceed twenty thousand feet in height, while peaks exceeding fourteen thousand feet occur in the Altai, and from ten thousand to twelve thousand feet in the Sayan. These are not marginal features of present-day continents, nevertheless they are arranged peripherally to ancient stable blocks, and to-day they represent the revival, by undulatory uplift, of sediments which were closely folded and overthrust during Hercynian movements. Now there are other ranges in the neighbourhood of Lake Baikal which form the borders of the ancient nucleus of Angara Land, and these

[6] Andrews, E. C., "The Origin of Modern Mountain Ranges", *Jour. Roy. Soc. N. S. Wales*, 1934, pp. 251-350.

[7] Chamberlin, R. T., "Significance of the Framework of the Continents", *Jour. Geol.*, 1924, p. 553 et seq.

represent the revival of Caledonian mountains. These revived Caledonides, which are now grouped round Angara Land, are generally of considerably less vertical relief than the revived Hercynides just mentioned, and which are arranged sympathetically with them to the west, south, and south-east.

Again, the old stable blocks of Angara Land, the lowland area lying east of the Urals, the Gobi, Ordos, eastern Turkestan, the Chinese Basin proper, together with the ancient rocks occurring along the eastern or coastal strips of China and Korea, represent portions of ancient nuclei and borderlands, and these, it may be noted, are not the sites of the great modern mountain ranges of Asia. In passing, it may be noted that the Mesozoic and Tertiary mountain areas of the Anadyr Peninsula of Sikhota Alin, Sakhalin, Japan, Formosa, and the Verkhoyansk zone are revivals of uplift along folded areas of Mesozoic and Tertiary age. In these areas also uplifts of Palaeozoic folded ranges are of common occurrence.

The mountain systems of Europe are extremely instructive in this connection. The Alpine system, in its larger sense, including the Pyrenees, the Spanish Sierra Nevada, the Apennines, the Dinarides, the Carpathians, the Balkans, and the Caucasus, are pre-eminently the grand ranges of the continent. All are arranged peripherally to an older framework. The topographic revolution which gave birth to the great Alpine system commenced in the closing Cretaceous (or even earlier) and reached a maximum in the Tertiary, the ranges so formed being worn down in a marked manner during the later Tertiary and then raised to their present exalted positions during closing and post Tertiary time. The "crystallines", which occur in the high Alps and in the related ranges of the same age, probably are Palaeozoic and Tertiary intrusives, in great measure, rather than fragments of ancient pre-Cambrian axes.

But to the north-east, east, north, and north-west of the Alpine system, the attention of the geologist is arrested by the peculiar appearance of the Urals, the Sudetes, the Erzgebirge, the Bohmerwald, the Fichtelgebirge, the Harz, the Thuringerwald, the Rhine Mountains, the Schwarzwald, the Vosges, the Central Plateau of France, the mountains of Wales and western England, the Scottish Highlands, the mountains of Scandinavia and of Spitsbergen. These are plateaus rather than Alpine ranges. They attain no great heights, nevertheless their profiles are grand and bold, and their stage of dissection is that of vigorous youth. It is well known now that the Scandinavian, Spitsbergen, Scottish, and Welsh plateaus are merely closing Tertiary undulatory uplifts of ancient and noble Caledonian ranges, while the other forms mentioned, such as the Ural, the Black Forest, and the Vosges, are undulatory uplifts, during the closing Tertiary, of the European Hercynides. These remnants of former grand Caledonian and Hercynian ranges are arranged peripherally to the stable areas of the Baltic nucleus, the Russian Platform and the north European Plain. The ancient pre-Cambrian basements appear only at considerable heights above sea-level in Europe in those places where they have been involved in Caledonian, Hercynian, or later compressions and thrustings. Other important points are considered in the following chapter on "Ancient Mountains".

In North America the Canadian Shield and the Stable Central Area of Schuchert are fringed with mountain systems arranged en echelon and in subparallel curves. These include the grand compound Cordillera in the west, the Arbuckle, Ouachita, Wichita, and associated masses in the south, and the Appalachian group, together with its related structures in the east. The same peculiar structural relations are noted in these American mountains as in the Asiatic and European examples, namely, that the areas which had experienced

marked compression during the later Mesozoic and the Tertiary are those which were re-elevated during the closing Tertiary and the Pleistocene to form the real mountain grandeur of the continent. It is the Rockies, the Sierras, the Alaskan, Cascade, and Coastal Ranges, to which the topographic magnificence of North America is due, whereas the Appalachian, Ouachita, Wichita, Arbuckle, and their related structures are mild and dwarfed forms as compared with the western Cordillera, and this despite their striking and picturesque profiles and their profound dissection by streams. They are stunted highlands, which represent the revival of uplift, in late geological time, of Caledonian and Hercynian fold mountains, and which appear, formerly, to have possessed alpine magnificence. The apparent exceptions to this general statement, which occur among the masses of ancient gneisses in the Rockies and in coastal Labrador, are discussed later.

South America presents similar features to those of North America. In the west, the mighty Andes represent late and post Tertiary undulatory uplifts of zones which had been folded strongly during both the later Mesozoic and the Tertiary. In the east the Brazilian ranges, which lack the majesty of the Andes, represent late revivals of uplift along Hercynian zones of compression.

In the continents of North and South America it is the enormous nuclei of ancient "crystallines" which occupy, generally, the lower continental levels. This was noted also in Asia and Europe.

The peripheral ranges of Africa—for example, the Atlas in the north-west and the Cape Ranges in the extreme south—present similar examples of contrasted types; the higher north-western group has a history somewhat resembling that of the European alpine types, while the southern group are closing Tertiary revivals of Hercynian and early Mesozoic systems.

Australia, with its closely related insular arcs, possesses similar structures. In this region the younger arcs of folding occur in open order, and are separated from the old mainland by broad seas, whereas, in North and South America, the mountain arcs, of Mesozoic and Tertiary age, have been shrunken tightly on to the mainland.

In the Australasian region, again, it is the areas which were closely folded during the late Mesozoic and Tertiary that have been re-elevated, in undulatory form, during the closing and post Tertiary, and which culminate in the grand compound chain of New Guinea. The closely folded areas of the later Mesozoic in New Zealand have been uplifted in late geological time to form the magnificent Alps of southern New Zealand, whereas the areas in that same south island which experienced their great compression during the Palaeozoic have been raised to heights much less during the same closing Tertiary uplift.

On the mainland of Australia itself the eastern highlands, together with the Mount Lofty, Flinders, and Macdonnell Ranges of the more central mainland areas, are youthful undulatory uplifts of the intensely subdued Caledonides and Hercynides.[8] All these highlands of the mainland, with their bold, youthful profiles, are arranged peripherally to the ancient nuclei of northern Australia, south-western Australia, Broken Hill with its extensions, and the Queensland Platform. The vast positive nuclei, composed of early pre-Cambrian structures, rise as gentle undulations from the negative area of the Queensland Platform and from the sites of the Palaeozoic geosynclines. They present their steeper slopes to the ocean.

[8] Andrews, E. C., "Structural History of Australia during the Palaeozoic", *Jour. Roy. Soc. N. S. Wales*, lxxi, 1937 (1938), 122-124.

A very important feature may be noted at this stage, namely, that although the great modern mountain ranges are due mainly to undulatory uplifts, in late geological time, of worn-down Palaeozoic, Mesozoic, and Cainozoic mountains, nevertheless, under certain peculiar conditions, the ancient rocks themselves have been involved in the last great undulatory uplift in a manner which has not been equalled, apparently, since the beginning of the upper pre-Cambrian. Generally, they have been uplifted in the form of vast, low, undulating shields, coinciding in position, generally, with the ancient nuclei, but in certain areas they have been brought into the zone of active erosive attack for the first time since the earlier Palaeozoic. These undulating domes, or shields, of tremendous radius, and with surface dip, of slight angular value, in certain areas have been warped or faulted to considerable height, while "Archaean" areas, covered by subhorizontal or gently undulating late pre-Cambrian or early Palaeozoic sediments, have, in places, been raised into the zone of active stream erosion. Thus, in North America, the Canadian Shield, together with its part-cover of subhorizontal Palaeozoic sediments, has risen, in broad undulations, in such form as to threaten the very existence of the relatively thin cover of Upper pre-Cambrian and Palaeozoic sediments in the immediate geological future; the ancient rocks of the coastal area of Labrador have been bent upward for many thousands of feet; the "Archaean" rocks of the Front Range of the Rockies have been warped in places to heights exceeding fourteen thousand feet above sea-level; the Grand Canyon Series, together with the relatively thin subhorizontal sediments of Cambrian age and the ancient crystalline basin of these groups, in the Colorado Cañon, have been elevated in undulatory form for thousands of feet during closing Tertiary time, and have been exposed thus to powerful erosive activity for the first time, apparently, since the beginning of the Palaeozoic. In Greenland also may be observed the same great undulatory emergence, in recent time, of rocks of high antiquity, into the zone of powerful erosion.

In Europe may be noted the undulatory uplift of Fennoscandia and its youthful stage of dissection.

In Peninsular India the gently undulating Vindhyan sediments of upper pre-Cambrian age rest upon an ancient basement, both having been brought recently into the zone of active stream erosion. Similarly for the ancient rocks of the eastern Ghats (India), of Arabia, and of various localities in Africa, among which may be mentioned the Union of South Africa.

South America presents a similar undulatory elevation, in late geological time, of the ancient crystallines of Brazil and of the southern cordillera of Chili.

These features are exhibited well, also, in Australia, where the ancient nuclei occur as low, broad elevations. These, together with their extensive but relatively thin covers of upper pre-Cambrian and of lower Palaeozoic and younger sediments, are being actively dissected, nevertheless, they appear to have been raised into the region of active stream dissection only recently in geological time.

Grandest of all, probably, is the example of Antarctica, where the ancient basement, capped by subhorizontal or gently undulating Palaeozoic sediments, has been raised in very late geological time to form a mighty escarpment extending for more than a thousand miles along the western side of the Ross Sea. Debenham[9] states that the escarpment rises in places to heights of fifteen thousand feet above the sea, and that the "Archaean" basement itself rises precipitously to heights of eight thousand to ten thousand feet, and probably more, above that same datum.

[9] Verbal communication.

The valleys dissecting the escarpment are all extremely youthful, thus indicating the recent emergence of the mountain mass. The trough of the associated Ross Sea appears to be a compensatory downwarp.

It may be noted that these great undulatory elevations of the pre-Cambrian basements, in late geological time, differ somewhat from other uplifted forms like the Himalaya, Kuen Lun, and Thian Shan, in that they do not appear to flow, or move, outwards as overfolds on their bases. They are relatively rigid and rise typically as enormous shields co-extensive with the basements of the vast negative areas of the continents.

This notable emergence of the ancient basements to form the present continental shields appears to be related intimately, from a structural point of view, with the downwarping of the old borderlands, in great measure, to ocean depths, and to the great accentuation, in late geological time, of the forms assumed by the ocean "deeps". Other significant features associated with this marked emergence, in late geological time, both of ancient basements and of post pre-Cambrian folded sediments, include the repeated revival of stream courses along the general direction of their old tracks and the association of repeated ice advances during the Pleistocene.

At first sight, the student might be inclined to explain these glaciations, of late geological time, as being due to the general pronounced emergence of the continental areas, and to the formation of mighty ranges of the Himalayan, Cordilleran, and Andean type, but the repeated world-wide advance and retreat of cold conditions, combined with the youthful dissection merely of the upraised areas, suggest that other contributing factors must be expected. The peculiar valley-in-valley structure, associated with the stream-carved valleys of modern mountain and plateau systems, sheds a flood of light on the methods of undulatory uplift, and, incidentally, should be kept in mind when studying the origin of Pleistocene ice ages. These points are reserved for later discussion.

Some Salient Features of Ancient Mountain Systems.

Various writers have considered former mountain systems from different viewpoints, for example: Chamberlin,[10] from their sympathetic trend with the continental margins existing at the time of formation; Suess,[11] from the structural resemblances between the Alps and the Hercynides of Europe; Keith,[12] from the relation of batholithic intrusion to folding; other writers from the viewpoint of crustal shortening, method of uplift, and so on.

In the consideration of North and South America, Chamberlin[13] states: "The ancient pre-Cambrian folded ranges and batholithic intrusions, as brought out by Ruedemann, trended northeast-southwest in Quebec and Ontario, becoming essentially east and west in the vicinity of Lake Superior . . . In the northeast, the remarkable parallelism between the pre-Cambrian trends and the present coast of Labrador has been brought out by Daly . . . On the eastern side of South America, throughout the length of Brazil, the ancient trends, still visible in the mountains of to-day, are scarcely less striking in their relation to the present shores."

In noting the marked parallelism of various ranges in the Union of South Africa and the general trend, as described by Rogers and Du Toit, of the southern

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[10] Op. cit.

[11] Suess, E., "The European Altaids and their Correlation to the Asiatic Structure", in "The Structure of Asia", 1929, pp. 35-57. Methuen.

[12] Keith, Arthur, "Outlines of Appalachian Structure", *Bull. Geol. Soc. America*, 34, 1923, pp. 309-380.

[13] "The Significance of the Framework of the Continents". Op. cit., pp. 554-555.

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end of the continent, he states[14]: "This marked tendency of the folded ranges to form parallel to the margins of the continents does not seem to have been confined to any particular episode in the earth's history, but, on the contrary, has characterized, in varying degree, the whole span of known geologic time from the Archaean to the present."

In confirmation later of this he describes[15] the sympathetic trends of the Laurentian, Algoman, and Killarney mountain belts of the southern portion of the Canadian Shield.

Although Chamberlin considered that this peculiar influence of the ancient nuclei had a world-wide application, nevertheless he stated his difficulty in fitting certain areas, namely, Australia, the Urals, and Peninsular India, into the scheme.[16]

The accompanying notes on the general trend of ancient mountain structures in Australia and India are supplied in confirmation of Chamberlin's generalization. The excellent example of the Urals has been mentioned in the note on the structural history of Europe. Only the pre-Cambrian trends of Australia are considered at this stage, the Palaeozoic trends having been mentioned briefly above when describing the structure of Australia.

Peninsular India[17] is crudely triangular in shape, with a broad convex base, the convexity being directed northward. It is composed mainly of ancient rocks and is surrounded on the north-west by the Baluchistan and Suleiman mountain chains; on the north by the Himalaya; on the north-east by the northern portions of the Burmese arcs. Between these vast outlying mountain systems and Peninsular India proper lies the curving plain of the Indo-Gangetic alluvium, representing the filling of a vast depression, whose main axis runs subparallel to the structural trend of the high mountain systems above mentioned. The latter, therefore, appear thus, directly or indirectly, to be related structurally to the ancient mass of Peninsular India; the negative area, which is now concealed beneath the Indo-Gangetic alluvium, represents the depression of the foreland of India proper as the Himalaya and its related chains undulated towards it.

If attention now be directed to Peninsular India itself it will be seen to consist of an "Archaean" basement, overlaid in part by, and intergrown in part with, younger but in many instances pre-Cambrian structures. Examples include the ancient and profoundly eroded Aravallis, which extend from the neighbourhood of the Little Rann of Kutch towards Delhi. The main trend of the range is sympathetic with the young massive mountain arcs which rise on the farther side of the plain of the Indus; the Vindhyan system, gently undulating on the ancient basement and forming the northern escarpment of Peninsular India, and facing the Gangetic Plain; the ancient Dharwars, their intricate and winding strikes following broadly the western trend of the Peninsula; and the folded Cuddapahs which appear to form arcs along the eastern coastal area. Reference is made later to these significant structures when considering the possible existence of an extensive "Gondwana Land".

The arrangement of the pre-Cambrian structures of Australia, so far as they are known, is highly informative. At the outset, however, it must not be forgotten that our knowledge of the structural geology of this continent is of a very general nature only. A very small proportion, probably less than two per cent., of the

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[14] Op. cit., p. 561.

[15] "Shifting Orogenic Belts of the Southern Canadian Shield", 1937, pp. 663-681.

[16] "Framework of the Continents", pp. 557, 560, 561.

[17] The structure of India has not been described sufficiently in official publications to allow the writer to draw more than a very tentative inference concerning it.

total area, has been surveyed in anything like detail. On the other hand, however, the tireless efforts of the pioneers of mining have enabled a crude skeletal picture of continental structure to be drawn. Thus various mining centres of importance have been examined somewhat carefully, and by a correlation, wherever possible, of the structures found therein, a general idea of the history of the continent has been gained.

It would appear that the immense south-western mass of Australia forms an ancient nucleus, within which lie various mining fields such as Kalgoorlie, Southern Cross, Sandstone, Yilgarn, Pilbara, and Wiluna. The pre-Cambrian folds of the nucleus are highly interesting wherever they have been revealed by mining examination. In the central and eastern portions of the nucleus the direction of folding is approximately north-north-west; in the Pilbara district it is west-north-west to north-west (that is, parallel to the shield margin); in the Macdonnell, James, Everard, Levi, Warburton, and other ranges which follow the great east and west sweep of the northern portion of the nucleus, the trend of the folds is also east and west approximately; in the south and south-east, the Stirling and associated ranges to the east, follow the periphery of the "Archaean" nucleus for great distances; while Maitland records the "grain" of the ancient basement as being sympathetic with the general trend of the coast around the south-western angle of the continent. Thus the trend, not only of the Lower Palaeozoic, but of the pre-Cambrian ranges, appears to follow the general margin of the vast south-western nucleus of the continent.

In the extensive ancient shield of northern Australia (Stuartiana) the general trend of the folds in the south is similar to that of the folds on the northern margin of the south-western nucleus or Yilgarnia, that is, east and west. On the eastern portion of the nucleus, the trends in the Cloncurry district are almost meridional and approximately parallel to the margin of the nucleus. In the northern portion, it was Wade[18] who first indicated the peculiar structures where the pre-Cambrian trend assumes the form of three huge curves with convexities directed southward, and where they appear to mark a stage in the structural development of the nucleus, as though in response to some powerful activity directed from the north. The adjustment of these curving trends to the long east and west sweep of the fold strikes of the Macdonnell, Everard, James, Petermann, and other ranges of central Australia is suggested by a striking passage in Woolnough's report on the Tennant Creek area.[19]

The Tennant Creek Gold Field is situated several hundreds of miles north of the Macdonnell Ranges, and the long east and west trends of the folding and of the schistosity appear to persist throughout the wide intervening area. Woolnough states: "Schistosity is everywhere very pronounced, the main axis being always nearly east and west. This axial trend, visible in many of the oldest formations throughout Australia, is in marked contrast with the dominant fold axes of the continent, and constitutes one of the major peculiarities of the region. The swing back into the meridional axis occurs about Banka Banka, and is complete about one hundred miles north of Tennant's Creek. This change of axis is one of the most remarkable features the writer has ever seen from the air."

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[18] Wade, Arthur, "Petroleum Prospects in the Kimberley District". Commonwealth of Australia, 1924, pp. 9 and 10.

[19] Woolnough, W. G., "Tennant Creek Gold Field, N.T.". Bull. 22, 1936, p. 25. Govt. Printer, Canberra.

The peripheral arrangement of the pre-Cambrian fold axes in the Willyama nucleus and its former extensions is readily noticeable in the field.

Suess,[20] in discussing Argand's brilliant synthesis of Asiatic structure, draws attention to the great assistance in the study of Asia which is to be expected from an application of the principles discovered during the detailed examination of mountain structures in Europe. His description of certain Hercynian mountain systems of Europe may be taken, in passing, as typical of the structural features which may be expected in the zones of marked compression, of various ages, in the several continents, including Australia.

In approaching the problem, he states that: "The Bohemian massif, the Harz, the Black Forest, the Vosges, the Central Plateau of France, and the Armorican Peninsula, are fragments of the older Variscan and Armorican Arcs. . . . Recent investigations have brought evidence that the original Variscan mountain chain of which now only scanty remains are left, was once not inferior in size and extension to the Alps of to-day, which are more completely preserved. Indeed, an additional important structural division was joined to the Variscan Chain, of which there exists no corresponding equivalent in the Alps."

Continuing this description, he states that a reconstruction of the Hercynian trend-lines of the existing mountain blocks, enumerated in the preceding paragraph, indicates that a broad belt in the north is the only one which is strictly comparable with the Alpine system. In breadth it is less than half of the whole structure, and occupies a position between the outer zone in the Westphalian coalfields and the southern boundary of the Erzgebirge. This zone is a fine example of the result of powerful compression, and has a striking likeness to an Alpine chain. With progressive advance in a southerly direction from the outer (northern) border of this ancient mountain system to the interior of the zone, the depth from which the outcrop has been uplifted not only increases, but the degree of metamorphism also is intensified. To quote Suess again: "The outermost zone, approximately corresponding to the Alpine Flysch-zone, contains the well-known extensive flat overthrust of the Belgian and French Carboniferous. The next zone to the south comprises the early Palaeozoic sediments of the Rhenish Mountains and of the Harz; . . . the third zone has been pushed forward against the second zone. It is characterized by the predominance of the crystalline rocks; and there is overwhelming evidence that it consists of a system of overthrust sheets and of blocks piled up and driven northward."

In this third zone of Suess, the core and foundation consist of the arches of gneiss of the Erzgebirge, which, in turn, are recognized as a group of flat overthrust folds forming a cover to altered granite cores. Superimposed in turn on these gneiss arches lie the eroded remnants of great thrust blocks composed of highly crystalline rocks. These, apparently, have been transported from the south. This idea is supported strongly by the knowledge that much of the Bohemian massif, the greater portion of the Black Forest, the Vosges, and the Central Plateau of France, are composed of this class of gneiss. Suess points out that, in the sedimentary complexes of Bohemia, of early Palaeozoic and late pre-Cambrian age, granite intrusions have produced marked metamorphism under the influence of high temperature, and that the strike of the rocks is not in one or a few prevailing directions, but that it conforms on the whole to the marginal trends of the larger granitic batholiths. Such an occurrence Suess has named an

[20] Op. cit., pp. 41-52.

"intrusion tectonics" complex. In this region also there has been rather close folding with overthrusting. The portion of the region of "intrusion tectonics" that belongs to the Bohemian massif appears to have been driven as a great and relatively rigid mass against the thrust slices which compose the Erzgebirge. Other parts of the Bohemian massif have been pushed beyond the Erzgebirge to the north and west.

Suess points out also how, as in the Alps, the granites of the Variscan mountains 'have crossed the surface of principal overthrusts or zone of "roots" and have penetrated into the folded zone or orogen proper', and he infers that a more profound stage of erosion of the Alpine Dinarides would reveal the existence of extensive granite masses, the intruded schists having dipped into the region of "intrusion tectonics".

He pursues the structural similarity of the modern and the Hercynian Alpine chains further by demonstrating that both may be considered as "continental-border-mountain-ranges"; that the geosynclines with their massive sedimentary sequence—the one with the "schistes lustrés" of the Pennine Alps, the other with the shales of the Rhenish zone—represent foredeeps which migrate before the thrust blocks only to be overridden at a later stage in the compressive activities of mountain making.

He draws attention also to another similarity of occurrence in the earlier history of the sediments of the Alpine and Hercynian areas. In the example of the Variscan mountains the widespread unconformity of the Lower Carboniferous overlaps the "various deeply eroded elements" and the material of that stage consists, in great part, of crystalline material derived from the core of the chain; similarly for the Alps, where the Upper Cretaceous (Gosau) rests unconformably upon the deeply eroded folded rocks of the older phase.

Students of Caledonian and Hercynian activities in the British Isles, in Scandinavia, in Spitsbergen, North America, and other localities, may recognize similarly complex phenomena of thrusting, "intrusion tectonics", and so on, in those areas. Keith describes an admirable example[21] of the influence of batholithic intrusion in the Appalachian structures of North America. In his opinion it is the intrusion by great granitoid masses which has been responsible, in very great measure, for the folding of the Appalachian sediments.

It is to be expected that phenomena of the types described above for areas of severe compression and "intrusion tectonics" in Europe, Asia, and America, occur also in Australia.

Hypotheses of Continental and Oceanic Development by Wegener and Others.

Wegener's hypothesis of wandering Poles and of a disrupted Pangaea—presenting a picture of the units born of such disruption wandering separately in various directions and giving rise later to the present continental forms—appears to have originated in a desire to throw light on various major problems in geology, examples of these problems being the peculiar shapes and locations of the continents, the suggestion of symmetry exhibited by the long eastern and western coast lines of the Atlantic, the location of the marked glacial activity of late Palaeozoic time, together with the geographical distribution of the Glossopteris flora, the angiosperms, and the mammals.

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[21] Keith, A., "Outlines of Appalachian Structure". *Bull. Geol. Soc. America*, 1923, pp. 309-380.

Schuchert,[22] Lake,[23] Taylor,[24] Wright,[25] Keith,[26] and many others have discussed the Wegenerian Hypothesis from various points of view. The points selected here, among others, for brief discussion, are the permanence or impermanence of the continental positions in a broad sense, the geographical distribution of the Glossopteris flora, together with the distribution of the angiosperms and the higher mammals.

At the outset it may be stated that, to most field geologists of wide experience, the more the actual stratigraphic and tectonic history of the continents is studied in detail, the more does the progressive growth of continental stability approximately "in place" appear to become evident.

Consideration, perhaps, may be directed first to the evidence from the viewpoint of continental structural symmetry. Keith, in discussing the structure of North America, states[27]: "I am convinced that it is reasonable to accept . . . the doctrine that the continental shape and size have been roughly constant from the present day far back into the pre-Cambrian. Around its margins were deposited in the ocean thick lenses of sediments; from the shallows of the ocean margin long narrow geanticlines rose in response to thrustings from the ocean. These geanticlines grew higher and higher, thrust was repeated, and finally culminated. Then the geanticlines were united to the mainland and a period of relaxation and tension followed. The surface of the earth was gradually worn down and quiet reigned. The order of the chief events in a revolution . . . is seen . . . to have occurred at least three times since the Cambrian."

Keith also points out that the permanence of the sea margin in North America is opposed to Wegener's hypothesis that the United States formerly fitted in between Europe and Africa. He shows that the present form of their opposed outlines, which is employed to support the idea of rupture, would not be those of oceanic shorelines, but, on the contrary, would be those of the more central parts of the former continent when in its disruptured state. The sea margins of eastern America appear to have existed for ages approximately in their present position. This, at least, is the view which most experienced field geologists might be expected to adopt. In passing, it may be stated that the apparent stability of South America during the ages is probably more apparent even than that of North America when judged by its stratigraphic and tectonic history, as outlined above.

This development of continental stability "in place", during the sedimentation of geosynclines and the conversion of their contained sediments to mountain ranges, appears evident indifferently, whether the Appalachian, Cordilleran, Andean, Iranian, Himalayan, Macdonnell (Australia), or other geosyncline, be considered. In each a picture is gained of subsiding troughs undergoing sedimentation during the ages, yet maintaining their relative positions with the ancient stable areas without the distortion and rupture implied in Wegener's hypothesis of a thin, non-homogeneous shell of brittle material wandering through a dense mass which acts approximately as a solid body to sudden blows. One example

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[22] Schuchert, C., "The Hypothesis of Continental Displacement". From "The Theory of Continental Drift", pp. 104-144. Printed in U.S.A. (with references).

[23] Lake, P., "Wegener's Hypothesis of Continental Drift", *Nature*, 1923, pp. 226-228.

[24] Taylor, F. B., "The Lateral Migration of Land Masses". *Jour. Wash. Acad. Sci.*, 13, No. 20, 1923, pp. 446 et seq.; "Greater Asia and Isostasy", *Amer. Jour. Sci.*, xii, 1926, pp. 47-67.

[25] Wright, W. B., "The Wegener Hypothesis", *Nature*, Jan., 1923, pp. 30-31.

[26] Keith, A., "Structural Symmetry in North America". *Bull. Geol. Soc. America*, 1928, pp. 374-388.

[27] Op. cit., pp. 383-384.

only, among many similar structures, may be selected for brief mention, namely, the Himalayan geosyncline.

The mapping and examination of this structure for many years by the Indian Geological Survey show that it has faced Peninsular India in the form of a relatively narrow earth depression (with its main axis tending to advance southward) since upper pre-Cambrian time. With the exception of the unconformity between the Carboniferous and the Permian, its history shows a conformable sedimentary succession into the Tertiary. It was a marine seaway during the Palaeozoic, with the exception of temporary regressions, and conformable marine successions obtained during the Permian, Triassic, Jurassic, and Cretaceous. The seaway narrowed, both during the closing Cretaceous and the post-Nummulitic, owing to the growth of a gigantic geanticline within it. There were three major phases of the undulatory uplift of the Himalayan system. The first occurred about the middle of the Eocene, and this is believed to have brought up the central axis of ancient rocks. The second occurred about the mid-Miocene, converting the terrestrial Miocene sediments into what are known as the inner lesser ranges. The third elevated the two former zones, together with the outlying terrestrial Siwaliks, into the present Himalaya. This third phase appears to have been closing Tertiary in age.

The results of this sequence of operations suggest that they developed in one locality without major disturbance other than that caused by undulatory subsidence and later uplift with the accompaniment of southward overthrusting. Even the method of undulatory uplift by which the present grand complex and compound Himalayan system originated indicates that streams such as the Ganges, the Indus, the Brahmapootra, together with their many powerful tributaries, maintained their original courses against the repeated uplift of the opposing mountain chains. The structural unity of this grand geosynclinal area could scarcely have been preserved intact through the ages, during the fateful wanderings inferred by Wegener, unless it be assumed that the enormous area of Asia, with its relatively negligible thickness of brittle rock, and its marked lack of homogeneity, had floated in a frictionless medium, and in one fixed direction. This assumption does not appear to be supported by the findings of geophysics.

The Appalachian, Cordilleran, Andean, Franciscan, Tasman (Australia), and other geosynclinal areas had histories of long continued sedimentation between borderlands and stable areas in a manner such as to suggest sedimentation in areas of fixed location except for inconsiderable modifications. Other great geosynclines, such as those of central Europe, the Uralian, the Mongolian, Nan Shan, Kuen Lun, and other types, have had histories of long continued and steady sedimentation around the margins of the ancient stable blocks, with subsequent welding of same to the marginal areas of these masses. Thus the structural histories of Europe, Asia, the Americas, Africa and Australia suggest growth of stability approximately "in place", rather than long continued and drift-like wandering of blocks, from a disrupted primeval mass, and, like plankton, following no settled plan of direction of movement.

Geographical Distribution of the Angiosperms and Mammals.—The peculiar geographical distribution of the angiosperms can be explained most simply, and satisfactorily, on the assumption that they originated in Holarctica, approximately in the lower Cretaceous (or upper Jurassic?), and that they experienced a wonderful adaptive radiation during the upper Cretaceous, accompanied by rapid dispersal along routes which followed the general trend of the present con-

tinental masses. With later change of climate and the isolation of large areas by the formation of natural barriers, this cosmopolitan flora underwent profound local modifications, with the production of vast endemic genera in Australia, South Africa, South America, New Zealand, and other countries. On the other hand, the assumption of continents filling the Indian and South Atlantic Oceans, or even of land bridges across the Atlantic, Indian and Pacific Oceans, leads the student of angiospermous distribution into incredible difficulties.[28] This is especially evident in the geographical distribution of many large families, such as Myrtaceae, Rutaceae, Ericaceae, Compositae, Labiatae, Verbenaceae, Euphorbiaceae, Fagaceae, Salicaceae, Ulmaceae, Aceraceae, and Rosaceae, together with many large genera, such as *Eucalyptus*, *Rhododendron*, *Quercus*, *Aster*, *Hieracium*, *Acacia*, *Astragalus*, *Erica*, *Podalyria*, *Leucadendron*, and *Melaleuca*.

If we assume, as some writers do, that the so-called "peculiar" vegetation of Australia has been derived from South African stock, transported thence along a broad land mass filling the Indian Ocean, we are faced at once with the difficult task of explaining the absence of various large subfamilies, tribes and genera from Africa which occur in Australia, and the absence of others of the same age from Australia which flourish in Africa. The Proteaceae is divided into two large subfamilies, one only of which occurs in South Africa, but both of which are very well represented indeed in Australia, while America and south-eastern Asia possess members of the subfamily which is not present in Africa. Furthermore, none of the large genera of the Proteaceae in Africa occur in Australia, and no Australian genus of the family has any representatives in Africa. The large family of the Ericaceae is magnificently developed in South Africa, *Erica* alone possessing about five hundred endemic species there. The whole family itself is absent from Australia, except for the presence of several highly specialized and locally modified waifs (*Gaultheria* and *Pernettya* in the south-east, and *Wittsteinia* in the north-east). Similarly, the whole of the *Eucalyptus* or *Leptospermum* division of the Myrtaceae, totalling one thousand species, with *Eucalyptus* (350 species), *Melaleuca* (107 species), *Baeckea*, *Leptospermum*, *Callistemon*, and so on, is absent from South Africa. Moreover, the whole family appears naturally to be absent from South Africa.

The difficulties become equally great when a bridge between Africa and South America, or one between South America and Australia, is assumed. Very many cold-loving types of plants in South America have no representatives whatever in Australia. Thus, *Patagonium* (150 species), *Astragalus* (75–80 species), *Lathyrus* (20 species), *Haplopappus* (100 species), *Escallonia* (30 species), *Hieracium*, *Alnus*, and many others have no indigenous representative in Australia. Moreover, no members of the genera *Eucalyptus*, *Melaleuca*, *Leptospermum*, *Grevillea*, *Banksia*, *Hakea*, *Boronia*, *Olearia* or *Epacris* occur in South America.

On the other hand, it may be noted that the primary types of vast families such as the Compositae, Leguminosae, Rubiaceae, Labiatae, Rutaceae, Verbenaceae, Liliaceae, Euphorbiaceae, Myrtaceae, and so on, appear to have been of luxuriant arborescent or at least shrubby, woody types, belonging to a genial and moist climate such as occurs to-day in the fertile tropics and subtropics. In the Upper Cretaceous they had a cosmopolitan range, whereas, during the subsequent differentiation of climate and the isolation of South America, South Africa,

[28] Andrews, E. C., "The Geological History of the Australian Flowering Plants". *Amer. Jour. Sci.*, 1916, pp. 171-232.

Australia and New Zealand from the great northern blocks owing to the erection of natural barriers, the floras of these areas developed endemic tribes and genera, which present greater morphological differences, when compared with each other, than when each is contrasted separately with its present tropical representatives.

Thus the true *Aster* is herbaceous, with five hundred species, approximately, and is confined to the northern hemisphere (with one exception on the high plateaus of Abyssinia). The primary arborescent form appears to have perished in Holarctica during the severe differentiation of climatic conditions in the Tertiary, but became modified locally to the woody *Olearia* (110 species) in Australia and New Zealand, the woody *Felicia* (50 species) in South Africa, and to the arborescent *Chiliotrichium* and *Diplostephium* in South America. Each of these appears to be more closely allied to the true *Aster* than to each other.

The primary types of the Rutaceae are essentially magnificent and luxuriant arborescent forms, such as the widely spread *Xanthoxylum* and allied species in the fertile tropics. In Australia the endemic tribe Boronieae flourishes; in South Africa the endemic tribe Diosmeae; and in tropical America the endemic tribe Cusparieae. These various endemic tribes appear to possess greater morphological likenesses to the widespread tropical types than to each other. This generalization appears to be applicable to other important families of Angiosperms.

The Mammalian Distribution.—Matthew[29] has shown that the simplest explanation of mammalian distribution is by the hypothesis of development in Holarctica and the neighbouring areas with radiation southward along lands which were practically coincident in position with the present continents.

It is to be expected, naturally, that adaptive radiation must flourish locally if effective barriers are erected between lands formerly in communication with each other. In this way it was that the great *Eucalyptus* group and the phyllodineous *Acacia*, together with the endemic tribes in the families Euphorbiaceae, Labiatae, Verbenaceae, Rutaceae, Liliaceae, and so on, were developed in Australia after its isolation from south-eastern Asia during the Cretaceous. As opportunity offered, these new groups extended their range beyond their old home, but the law of Age and Area handicapped them severely so soon as they competed with the plant forms which had been evolved during the same period within the much larger area of the northern hemisphere.

The Geographical Distribution of the Glossopteris Flora.—White,[30] thirty years ago, in dealing with this difficult problem, proposed the name *Gangamopteris* rather than *Glossopteris*, for the flora under consideration. To the list of localities recorded by him in 1907, from which plant remains of this flora have been obtained, may be added Antarctica. The necessity for the existence of a vast Gondwana Land, occupying an area formed by the conjoined masses of South America, Antarctica, Africa, India, and Australasia, in order to explain the actual geographical distribution of the *Glossopteris* flora, does not appear to exist, inasmuch as a distribution, similar to that considered above for the angiosperms, but in the opposite direction, affords at once a more simple, and yet eminently satisfactory, explanation. The structures of the mountain ranges, mentioned above, are opposed to the hypothetical Gondwana Land.

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[29] Matthew, W. D., "Climate and Evolution", *Annals N.Y. Acad. Sci.*, xxiv, 1915, pp. 171-318.

[30] White, David, "Permo-Carboniferous Climatic Changes in South America", *Jour. Geol.*, 15, 1907, pp. 615-633.

The earlier Carboniferous flora would appear to have been of cosmopolitan distribution, and its nature is supposed to be indicative of fairly equable and mild climatic conditions. While these conditions were preserved in the main, apparently, during the Middle and Upper Carboniferous in the northern hemisphere, nevertheless, the climate in some parts of the southern hemisphere, for example, Australia, was undergoing a severe change. In these southern lands the cosmopolitan Carboniferous flora became adapted accordingly to meet the climatic differentiation, and, by the beginning of the Permian period, the *Glossopteris* flora had been developed. It has been found in the Permian of Antarctica, the Falkland Islands, Argentina, Brazil, South Africa, Australia, and India, also in a modified form in Tonquin, Kashmir, Afghanistan, Russia, and the Altai in Siberia. Of these localities, the southern hemisphere examples are true *Gangamopteris-Glossopteris* associations, whereas, north of India proper, they are younger assemblages and appear to represent a commingling of milder northern types with true *Glossopteris* assemblages. *Glossopteris* is not known to occur in the Mesozoic of the southern hemisphere, but the mixture of *Glossopteris* types and true northern forms survived into the Mesozoic in the northern hemisphere.

The *Glossopteris* Flora thus would appear to represent a modification of the milder cosmopolitan flora of the Carboniferous to meet the climatic conditions of an Antarctic land, probably an Antarctis, and that, at a later period, the members of this new group spread northward to the glaciated areas of South America, Australia, Africa, and India. The entry to South America may well have been by the Falkland Ridge; to Australia along a former arcuate zone now marked by a sunken ridge, and thence to India and Africa, or along another former land zone whose probable existence is suggested by other sunken ridges extending now from Antarctica towards Africa and India. In the southern continents they flourished during the glacial visitations. Thence they advanced northwards later through Kashmir, Afghanistan, and Persia, to Russia and Siberia, where there arose a commingling of modified cosmopolitan types and the survivals of the *Glossopteris* Flora which led again to the development of a widely spread flora in the Mesozoic.

An interesting feature of plant life to-day may be cited here as throwing light on the apparent anomaly that the Kuttung plants of Australia belong to an assemblage generally considered to be indicative of a genial climate in the northern hemisphere. An examination of the flora of eastern Australia reveals the fact that the dense growths of the rain-forest within the sheltered ravines and valleys of the coastal plateaus are surrounded by the xerophytic and stunted endemic plant growths of the barren sandstone plateaus and other wind-swept areas. Plant remains of both these types conceivably might well be preserved together in the silts of the neighbouring valley deposits. Let us consider similar associations to have existed in the past, then, provided that the luxuriant types were much more numerous among the fossil remains—as would be expected by reason of the proximity of the luxuriant types to the water channels—an observer would get the impression that he was dealing here with growths belonging generally to a genial climate. It is almost certain that deserts, and other inhospitable areas, have existed side by side with areas of luxuriant plant growths ever since the development of the angiosperms. The example of the widespread *Acacia* flourishing side by side with the luxuriant types of the upper Cretaceous and Tertiary may be cited in illustration of this peculiarity.

Walkom, in considering this problem of the existence of plants in the Kuttung (Lower Carboniferous) deposits generally referred to associations characteristic of a genial climate, draws attention to the present striking proximity of dense and luxuriant growths of ferns and other plants, subtropical in general appearance, to the great glaciers of the Southern Alps of New Zealand. These growths are covered usually with deep snowfalls during the winter. The important point to note, in this association, is that they occur in areas, not only of heavy and permanent rainfall, but also of marked protection from fierce cold and desiccating winds. In the Alaskan fiords, luxuriant plant growths exist under similar conditions of precipitation and of shelter from strong cold drying winds. Walkom points out that the survival of certain types, such as *Rhacopteris*, during the cold climate of the Kuttung, may be an adaptation of a cosmopolitan type, developed during a generally mild climate, to conditions of decreasing temperature, but of heavy precipitation and marked protection from strong cold and dry winds.

Argand's Hypothesis of the Structure of Europe and Asia.—The genius of Argand has presented us with a brilliant analysis of Alpine structures, particularly those of the western Alps.[31] His conclusion is that the northward drifting of Africa led gradually to the formation of the Alps, and that the Prealps themselves, in the northern portion of the Alps, represent a small portion of Africa upon Europe. Argand, moreover, has discussed the structure of Asia.[32] He gives the following picture: Asia consists mainly of the welded Siberian, Chinese, and Serindian (Tarim) massifs or nuclei. Since the Cambrian there has been a trial of strength, as it were, between the opposed movements of Eurasia and the so-called Gondwana Land to the south. The northern mass of Eurasia has had a relatively southerly drift, while the southern masses have had a northerly drift. These opposed movements closed the Tethyan Sea, and the southern masses, by their drive northward, gave rise to the Alpine, Himalayan, and related Tethyan systems. Towards the close of the Pliocene, the ancient Tethyan zone was reopened, by expansion, in its western portion, and a portion of Africa was left behind on Europe as the northern front of the Alps in the Lake Thun–Lake Geneva district. The northern chains of the Alps, together with the detached African fragment mentioned above, moved still farther north; the Mediterranean widened; and the Apennine chain moved from an original east-west to the submeridional trend which it now possesses. de Böckh and others, as the result of actual field work, consider that Argand's conclusions in some important structural points, are somewhat at variance with the known history of the Iranian geosyncline.[33] Attention in this note is confined to the European and Himalayan regions.

In approaching the problem of an assumed trial of strength between Africa and Europe (or Eurasia), two things become apparent at the outset, namely, that the continent of Africa has the general appearance of marked stability of long standing, and that the structural history of Europe has been complex and long continued. Such complicated history must be considered in any hypothesis involving the overriding of Europe by Africa.

Let is be assumed, however, that the Prealps are a part of an African overthrust, carried still farther north by later overthrusting. The question then rises,

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[31] Argand, E., "Sur l'Arc des Alpes Occidentales", *Compt. Rend. Congrès Géologique Internationale* XIII, Brussels, 1924, Vol. I.

[32] Argand, E., "La Tectonique de l'Asie", *Compt. Rend.*, 1924, Vol. I, pp. 171-372.

[33] de Böckh, H., Lees, G. M., and Richardson, F. D. S., "Contribution to the Stratigraphy and Tectonics of the Iranian Ranges", *Brit. Ass. Adv. Sci.*, 1928, in "The Structure of Asia", 1929. Methuen.

naturally, as to what caused the cessation of the northern drive of the relatively powerful African block at this stage, seeing that the subsurface activities are assumed to have persisted indefinitely in that direction. The natural sequence to a long continued activity, such as that assumed by Argand, would be the formation of a plateau across the present Mediterranean, fronted by great subparallel mountain crests (a grand compound Alpine system) accompanied by a foredeep on its northern front as in the example of the Indogangetic depression occupying the southern front of the overfolded and overthrust Himalayan mass.

This, however, is merely a passing reference to the African and European structures in late geological time. The pre-Palaeozoic and later tectonic history of Europe, sketched briefly above, throws light from another quarter on to the problem. The story commences with the formation of a great borderland on the north and of a vast nucleus—Baltica, with the Russian Platform foundation and its great western extension into Britain—around which lay a long geosyncline on the north, north-west, and south-west, while the extensive borderland lay beyond it towards the Polar regions, and to the west of the British Isles. The complex Caledonian mountain system grew out of this mobile area and heavy thrustings were delivered both southwards and northwards.

This activity resulted in the welding together of the ancient nucleus and borderland, a fragment of which appears to outcrop in the north-west of the British Isles. Although this grand effort at stabilization had occurred on the northern margin of the European nucleus, nevertheless mobile geanticlinal tracts still surrounded it on the east (the Ural and Timan depressions), and on the south, from the southern extremity of the Urals, to points in the Atlantic west of Ireland and Spain. Then followed the close folding of the sediments of these geosynclines with the overfolding and thrusting of the same northward, towards the southern margin of the nucleus, to be succeeded, still later in the Palaeozoic, by the welding together of the ancient blocks of western Siberia and of the Russian Platform. There appears to be no necessity to assume the formation of these folded systems by the drifting action northwards of an ancient mass; it appears simply to be a second stage in the gaining of stability within the broad zone separating the northern borderland, the ancient masses of Baltica, the Russian Platform, the western Siberian Platform, and Africa.

Later again, the Alpine foldings marked the addition of still another zone of stability to southern Europe. In this movement Spain and France were welded, or knit, together; the Atlas Mountains also marked a stable addition to Africa, with overfolding and thrusting southward. The Apennines and the Dinaric Alps appear merely as ribs of strengthening in the shrinking area of weakness separating the massive blocks of Africa and middle, with northern, Europe.

From this point of view, Africa appears to have acted simply as a resistant and stable mass throughout the Caledonian, Hercynian, and Alpine activities, by means of which the area between the African and European nuclei has been gaining stability gradually, while the ancient massifs meanwhile have simply undulated gently during the several revolutions in the topography.

The papers of F. B. Taylor, which have been stimulating in a marked degree, suggest a southward drifting of North America and Eurasia, the latter over a very great distance. The somewhat divergent views held by the writer are stated in the section following on "The Crust of the Earth".

The Crust of the Earth.

There appears to be a tendency among students of mountain and continent building to rely too exclusively on the study of ordinary geological maps and of

small terrestrial globes for suggestions about the main movements of the Earth as a whole, as well as about the principal activities within its crust. The necessity for maps and globes is evident, but a study of these alone is by no means a satisfactory substitute for a personal study of the great Earth itself, when search is being made for the origin of its main topographic forms. It is as though a student were to seek an explanation of the more subtle problems of biological activities on the Earth by confining his attention to ordinary museum collections. It is certain that the understanding with which Nature gathers itself up, as it were, would altogether escape him thus. The globe of the study is, for such examination as is here proposed, a rigid structure; it has no freedom of movement either as a body rotating rapidly on itself and yet possessing no visible means of support; as a body undergoing rapid translation in a frictionless medium; its own weight, moreover, is totally inadequate to beget a condition of subsurface flowage within itself. Many students, thus, in their search for a satisfactory explanation of the periodic advance and retreat of the sea over the continents, the loading and sinking of geosynclinal areas, the formation of folded mountain ranges, and other items in continental building, consider that the known movements of the Earth are insufficient to produce such features, and, in these studies, they feel constrained to invoke the aid of some complex activity, perchance even inoperative to-day, but certainly shrouded with an impenetrable veil of mystery.

On the other hand, the origin of mountain ranges, and associated world forms, appears to the writer to be explicable readily by the simple and well-known activities to which the Earth at present is subject; and as a contribution to the study of the origin of continental structures it is proposed here to take a general macroscopic survey of the crust of the Earth, and see what it may have to tell about itself. This, perhaps, may be introduced fittingly by a brief reference to the latest of the great world cycles of marine transgression and land emergence already noted, in part, in the previous chapter.

Marine transgression, during the Upper Cretaceous, probably was as pronounced as at any other recorded time in the history of the Earth. The land had been reduced to the low-lying stage; the extensive geosynclinal areas had approached the condition of overloading; the sea-level had risen, partly by sinking and reduction of the higher land forms, and partly by the transfer to the sea of the waste arising from the land reduction; there had been consequent shallow flooding of the land in the extra-geosynclinal areas, together with a general extension of milder climatic conditions. Then, gradually, following on this period of apparently increasing stability, various phases of powerful and complex mountain-making movements were developed, which, probably, have rarely if ever been exceeded in intensity since the commencement of the Palaeozoic. The Himalayan revolution, which succeeded to a conformable sedimentary succession during the Palaeozoic and the Mesozoic, save for an unconformity between the Carboniferous and Permian sediments, may be taken as a magnificent single item in this widespread activity of the post-Cretaceous.

In the structural depression within which this history took place, the sediments, at the close of the Cretaceous, began to rise, and were associated with an extraordinary display of volcanic and plutonic activity, the latter involving intrusions of granite, gabbro, and peridotite (serpentine). Close folding, which affected the Nummulitic limestone (Eocene), succeeded in the middle Eocene, and this activity uplifted the central axis of the ancient sediments and crystalline rocks. A later powerful movement affected, in a marked manner, the Lower Miocene, together with the older sediments. Overfolding and thrusting towards

the foreland of Peninsular India ensued, the action being extremely slow, the mountain chain thus formed actually overriding and ridging up the products of its own waste, the moving fault front also forming a continuous backward boundary to the deposition. This revival of mountain making in the Miocene was accompanied by another grand plutonic display, in which vast intrusions of granite, syenite, diorite, gabbro, and other igneous types, penetrated the Eocene sediments. This revolution was followed by a long period of denudation, the waste derived from the mighty ranges being deposited in the complementary trough separating the new ranges from the foreland. In this way, the terrestrial sediments, known as the Siwaliks, originated, attaining stratigraphic thicknesses in places of sixteen thousand to seventeen thousand feet. Undulatory elevation succeeded at the close of the Tertiary, culminating in the formation of the present Himalayan Ranges, which are probably as great as, or even greater than, their Tertiary forerunners in the same region. This latest movement was accompanied also by the undulatory elevation, not only of the Eocene and lower Miocene, but also of the outlying zone of the upper Miocene and Pliocene Siwaliks. Overriding of the Siwalik sediments occurred also in the younger frontal trough. Contemporaneously, moreover, with the elevation of the present Himalayan system came the formation and filling of the broad Indo-Gangetic trough, separating the Himalayan, Suleiman, and Burmese mountain systems from the Aravalli and Vindhya ranges in Peninsular India. This Himalayan elevation was merely the most severe local compression experienced during a widespread topographical revolution. With the general elevation, at the close of the Tertiary, was associated the oncoming of the Pleistocene Ice Age, with its periodic advances and retreats of severe climatic conditions.

Inasmuch as these happenings were confined to the geological yesterday, as it were, and, moreover, as they may be matched with a succession of activities of similar nature during earlier geological periods in other parts of the world, it may be assumed, temporarily, that the activities which produced these phenomena are sufficient to explain the various vicissitudes through which the Earth has passed since the early pre-Cambrian. In other words, they appear to be in full operation to-day, and they may be summed up as the Earth's rotation in a frictionless medium; its translation through space without rigid support; the tidal influences exerted by various celestial bodies; the pressure, by weight, of its heavy brittle crust on itself; and the negligible resistance (one atmosphere only), at the Earth's surface, to internal activities which are reacting towards that surface.

It may be helpful, in attempting to picture the natural outcome of these interacting activities and conditions, to imagine an observer viewing the earth, not only from points on the surface itself, but also from points situated many thousands of miles distant.

From the far-off viewpoint, the appearance is that of a huge globe, "hanging upon nothing", rotating swiftly but silently on itself, and possessing a great velocity of translation round a distant and much larger body, which, in turn, is moving towards another but much more distant point.

Several things attract the observer's attention from this distant vantage point. In the first place, the nature and degree of its rotation, as it floats unsupported by solid mechanism, explains the symmetry of its geometric form, for the interposition of any basal rigid support, such as a vast horizontal plate, would lead to rapid liquefaction of the whole with subsequent consolidation in tumultuous undulations. In the second place, he notes that the geoid approximates closely to an ellipsoid of rotation, with a flattening of the polar and a distension of the

equatorial regions, the axis connecting the Poles being considerably shorter (twenty-seven miles approximately) than the axes connecting appropriate geometric points on the Equator. From this, together with certain other facts to be noted later, he perceives that the figure of the Earth, in all probability, is determined by present terrestrial movements for, from his broad viewpoint, it seems certain that any notable wandering of the Poles would be associated with progressive flattening of the successive positions occupied by the Poles, and that the changing equatorial region would maintain its appropriate bulge. Furthermore, he has noticed that its surface has the appearance of being ornamented with undulations. Large and small, broad and narrow, high and low undulations are all well represented, some with steep slopes broken with faults, others with sides and summit slopes of small angular value.

In this he discerns one all-important difference, at least, between the small rigid globe of the study and this celestial orb, revolving before him in silent majesty, whose every movement and whose undulating surface suggest a grand and pulsating vitality within.

He perceives an explanation of this in the fact that the crustal rocks press downwards with a strength so great that a sudden release from the weight of the miles of overlying rock would induce a condition of flow straightway in the heated but solid subsurface rock layers. The scientific use of the imagination comes here to his assistance. He pictures some grand celestial being, Ithuriel perchance, rending the solid crust with that same magic spear which he was wont to use when searching for the truth in things on Earth which seemed, at times, to be what they were not. The gash made thus would seal itself, but the fresh surface thus formed would take on another shape; the sides of the gash would flow together and the surface would take on the form of a series of undulations decreasing in size outwardly from the centre of the rent, and lava floods would be discharged over the surface. The observer has not the use of Ithuriel's spear, but he has, for his sure guidance, the widespread and abundant evidence of local escapes from the pressure of the crust on itself, in the numerous centres of volcanic activity and in the vast masses of consolidated lavas of modern and earlier time now littering the Earth's surface.

This local fusion of rock material, with escape to the surface as opportunity offers, leads him to note that the rocks composing the outer crust are not tightly reinforced or bonded, but that, on the contrary, they are short in grain, as it were, being traversed by planes and zones of relative weakness.

He proceeds to assemble the knowledge gained at this stage, namely, that, firstly, the pressure on the subsurface material must produce a definite reaction, equal to the weight of the superincumbent material, towards the surface of the Earth; secondly, rocks suffer liquefaction under enormous pressure if they are insufficiently supported on all sides; thirdly, the pressure at the Earth's surface is negligible, being only one atmosphere; fourthly, the crust of the Earth is not of great and uniform strength such as it would possess if composed of toughened, unjointed steel, many miles in thickness, but is, on the contrary, of very moderate and variable strength; fifthly, rock material constantly does reach the surface in a molten condition; sixthly, the disposition of the surface features of the Earth are related to these escapes of material from pressure; and, seventhly, the form of the Earth is ellipsoidal or subglobular, a form which is extremely favourable for the endless subsurface transfer of material.

From a consideration of these points, he perceives that the deeper crustal condition is one of very unstable equilibrium, the weaker portions of the crust being markedly subject to rupture by the upward reaction towards the surface from the downward pressure of the upper crustal layers. He notes also that there are many zones where this upward reaction has overcome the downward pressure, and that, at these zones, the erstwhile solid, though highly heated, rock either has been poured out as lava at the surface or has entered the higher portions of the crust in liquid condition as sills, injections, dykes, or other well-known forms of igneous intrusion. A magnificent example of such mobile, or relatively weak, zone is the wide, outer marginal portion of the Pacific, especially on its western side. The more stable blocks, or those which are possessed of greater thickness and stronger bond (reinforcement by recrystallization in mass, or by other means), may be bowed up in the form of broad gentle undulations, nevertheless this undulatory movement of subsurface material is interfered with in places by actual surface rupture, with larger extrusions at the surface as the direct result of that deep-seated rupture.

With the intention of gaining more detailed knowledge of the surface forms, and the rock types of which they are composed, the observer now approaches the rotating Earth and circles it spirally from Pole to Pole. From this closer examination several additional facts, world-wide in distribution and interest, become evident. Thus each continent appears to possess great nuclei composed, basally at least, of ancient rocks, although covered in many places with younger formations. The arresting feature in these enormous occurrences is their appearance of relative stability. A careful examination of all the many stages of alteration exhibited by the rock formations, scattered over the Earth's surface, leads to the natural conclusion that the rocks composing these nuclei proper represent end-products of physical and chemical activities in ancient abyssal laboratories; the fuller statement and explanation of this, however, he defers until a slightly later stage in his notes. His tentative inference is that the rocks comprising these nuclei appear, in part at least, to have participated in a state of potential, or even actual, flowage, at an exceedingly slow rate; moreover, that they are now exposed at the surface by the joint action of the repeated elevation and successive erosion of former overlying rock masses. The deeper significance of this phenomenon escapes him at the time, his attention being arrested, temporarily, by the engirdlement of these nuclei, in places, with zones of folded rocks, the upper portions of whose formerly closed folds now appear to be truncated abruptly at the Earth's surface. All stages of dismantlement occur in these folded rocks, from those suffering only slightly from denudation to those whose cores or centres seem to have been exposed by elevation and erosion. In the latter forms, into which erosion has bitten very deeply, he perceives the influence of activities similar to those which appear to have produced the peculiar crystalline condition of the nuclei.

He notes also that all the present highland regions of the earth have arrived at their exalted position as the result of a series of undulatory uplifts, all in turn being separated by geosynclines, foredeeps, intermontane valleys, or other types of compensatory structures. The uplifts take place with relative rapidity, and are punctuated with intermediate and long continued conditions of approximate stillstand. Nevertheless, the uplifts themselves actually take place with extreme slowness as measured by human standards of the passage of time,

inasmuch as many strong streams, in all parts of the world, seem to have maintained their direction of flow against the undulatory uplifts opposing them.

It is seen thus that, as opportunity offers, there is a definite tendency for the transference of subsurface material to localities where the crust has not been strongly reinforced already by close folding and recrystallization. From the vantage points attained by the observer as he circles the world again and again, it seems evident that the escape of material to the surface is accompanied partly by explosive shattering of solid, overlying rock, and partly by discharge of lava. The greatest explosive action occurs in areas of heavy sedimentation which have been, or are being, raised as mountain systems or island arcs, whereas the greatest floods of basic lava have been poured out mainly on the more stable land masses such as the continental nuclei and their structural equivalents of later time. The basic deluges are more or less contemporaneous with the explosive phenomena, the two types being separated by great earth depressions.

The general transfer of subsurface material is effected, necessarily, in an undulatory manner, so as to maintain a state of equilibrium, stable or unstable, within the material of the portion of the crust affected, as is usual in the propagation of activities in physical media. In a vast spheroid, possessing a constant speed of rotation in one given direction, this transfer of subsurface material—which acts in the crust as a solid to sudden blows, but as a plastic mass to long continued pressure under heavy load—is not so much an actual wholesale translation of material as it is an essentially undulatory movement, each particle of the material tending to remain within its own major undulation, while the undulations themselves rise higher (mountains) and sink more deeply (intermontane valleys and other structural troughs) at places where the surface material offers less resistance. The undulations also decrease in height and size at places where conditions of more stable equilibrium exist.

Great actual translation of material may take place, however, at zones of relative weakness in the crust. Examples of this action are the transfer of material from sub-geosynclinal areas to the subsurface portions of the associated and mobile feeding geanticline, and the transfer later during the reverse process from the sinking area to the overloaded and disrupted geosynclinal area. His observations on the flattened condition of the polar areas, moreover, have shown him the high probability of the world-wide influence of a marked disruptive rise in an area of former heavy sedimentation, because the transfer of subsurface material to the collapsed area of sedimentation implies the necessity to maintain equilibrium, however unstable, in all parts of the world. Each earth undulation is approximately in equilibrium, or in balance with all others, directly or indirectly. The higher undulations, which crowd together, are characteristic mainly of the weaker earth structures, while the lower more open examples are found mainly in the stronger structures, inasmuch as these more rigid forms have a definite tendency to rupture by tension, with discharge of lava when uplifted beyond a certain height.

Furthermore, there is a strong tendency to a dual arrangement of the surface features of the Earth, acting through this undulatory movement in the crust, namely, a tendency, on the one hand, to move towards the Equator, as shown in the equatorial bulge, together with the closely folded and overthrust regions of Tethys, the West Indies, and the East Indies, and, on the other hand, in the tendency for the more plastic material to lag somewhat, in the form of arcuate

undulations round the more stable portions of the crust, as the Earth revolves from west to east.

It is at this point that a deeper significance is read into the rock structures composing the ancient nuclei. They are, as stated above, end-products of activities in the upper portion of the deep-seated laboratories of the crust, and they represent zones of this underlying region which have experienced the maximum rise known to man, from the deep laboratories in which their alteration had taken place. They indicate the changes which physical and chemical activities tend to produce in rock masses which lie somewhat above the abyssal portions of the crust. Despite their present appearance of crystalline stability and rigidity, it is evident that subsurface pressure (with its attendant heat and igneous intrusive action) and long continued time, had induced in them a state of semi-plasticity ages ago. An examination and correlation of the countless rock outcrops now dotting the surface of the Earth enables the observer to frame a natural and ascending sequence of metamorphic action, beginning with that exhibited in soils and in uncompacted sands, which show only a negligible amount of alteration, and passing thence through rock types exhibiting slight and moderate alteration only to the most altered types within the ancient nuclei. There must, however, he perceives, be depths still greater, yet varying from place to place, in the subsurface zone, where rock material exists in a condition of potential flowage, ready to enter the molten condition locally upon the least release of pressure. At depths still greater in the crust than those at which the outcropping nuclei were formed, the evidence of rock flowage and of plasticity would be much more apparent.

No trace, however fragmentary, of the original surface of the Earth has been seen by him. If the Earth really did originate as a rotating globe of molten material, no sign of a cool ancient surface has been detected; if, on the other hand, it grew gradually by the addition of other bodies to its mass and developed into a revolving body of compacted planetesimals, there is still no sign of its primitive surface. On the other hand, the oldest rocks exposed at the present surface are formed of sediments, derived from the waste by erosion of older land surfaces. These ancient lands, again, from which the waste was derived, appear to have been more siliceous than the basic lavas which occur so commonly as extensive flows or sheets on the great stable land masses. Moreover, this waste, by erosion, had been deposited in structural troughs, and, at a later stage, had been folded closely, buried deeply in part, and injected with molten rock material arising from local relief of pressure. Subsequently, these lower altered zones were raised successively, but gradually, into the zone of active erosion, thus, in turn, affording material for the filling of later and neighbouring earth depressions (geosynclines). Sedimentary belts of later date, with similar histories, were welded or knitted on to the nucleal masses in the form of marginal zones arranged subparallel to each other, both on the inside and outside aspects of the nucleal areas. The latter, in turn, are the oldest rock groups of which definite knowledge is possessed by geologists. Borderlands also were formed, at very early stages, as outer arcs to the growing nuclei. It is these nuclei and borderlands which have been undergoing the welding process from early pre-Cambrian time to the present. The vast lapse in time which separates the formation of the original rock surface of the Earth and the oldest rocks exposed to-day at the surface is plainly indicated. The observer perceives that the so-called "Archaean" rocks could never have been produced by surface activities; they are evidently the

product of abyssal laboratories; instead of being fragments of a primitive crust, they appear to be merely later forms in an uninterrupted succession of sedimentary depositions in geosynclines, followed by close folding of the sediments. Portions of the nuclei so formed were bowed down later to form the great negative areas as opposed to the positive examples.

All the phenomena of the present surface could be produced simply from an earth with a cold crustal layer, the deeper portions of the crust being solid but heated owing to the pressure of the upper layers, and being capable of yielding an endless source of world power and heat if only means could be found to tap such source of power with safety.

Reverting again to the subject of subsurface transfer, he notes that it occurs as an undulatory movement in the deep zone mentioned above—the zone definitely deeper than that in which the most altered types of the "Archaean" nuclei originated. Once this transfer is started, on a large scale, there is no rest until adjustment has been made throughout the crust.

Inasmuch as the structures of the upper portions of the ancient nuclei have been reinforced by their recrystallization and pressure, the undulatory movement of crustal adjustment experiences a considerable amount of resistance in its approach to, and subsurface traverse of, these stable areas. This resistance to subsurface movements results, partly, in the folding and overthrusting of the weaker masses of sediments towards these relatively stable areas. The Asiatic and Australasian insular arcs are examples also of this action in the western Pacific, while the North American Cordillera and the South American Andes are examples of the peripheral envelopment of stable blocks by the lagging action of the basic material apparently underlying the Pacific (as shown by the absence of continental rock types from its many and great volcanic discharges, and by the marked presence of basic lavas). The Atlantic appears to be undergoing a process of stabilization in the form of a long trough of great width separating the continents of America from those of Africa and Eurasia. This relative and growing stability of the Atlantic area, as compared with that of the Pacific, is indicated by the absence of severe compressive movements since the Palaeozoic, except at the intersections with the mobile areas of latitudinal disposition separating North from South America, and Europe from Africa. These, however, properly belong neither to the Pacific nor to the Atlantic regions, but merely represent mobile areas—separating huge stable blocks—affected by forces tending towards the equatorial region. Another feature indicating the tendency towards stability in the Atlantic is the Atlantic Ridge itself, and the minor deeps which accompany it along its eastern and western aspects.

In this process of stabilization the Atlantic Ridge has preserved a remarkable trend sympathetic with that of the continental margins bordering the Atlantic east and west. At a much earlier period it would appear that the Atlantic basin was somewhat deeper than it is at present, whereas the Pacific Ocean appears to be increasing in depth in many places; moreover, there appears to be an increasing instability of base in those portions of the Pacific where its depth is increasing in the most pronounced manner.

It is noted, however, that although the more stable land blocks oppose the subsurface movement, nevertheless their strength is insufficient to remain unmoved by its attack; they may not be folded, crumpled, and thrust in the manner suffered by the overloaded geosynclinal areas, nevertheless they are buoyed up

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as a successive series of wide undulations, of simple nature, during periods elsewhere of great mountain making.

From these studies, the observer is enabled, in an incomplete manner, to understand the successive stages of relative tranquillity, denudation, marine transgression, loading of geosynclines, and mountain making, which have left their traces from time to time in the surface rocks of the Earth. Geosynclines are formed, and they undergo continuous loading, and their foundations sink as the necessary complementary geanticlines rise; denudation of the geanticlines affords continuous supplies of fresh material to the troughs; the irregular axes of the troughs wander in some measure in response to variations in loading; the undulations of revived uplift diminish generally in height and volume with the passage of time; the sea-level rises, causing shallow flooding of the forelands and of the denuded geanticline also in part. The continuance of these activities and conditions results in the weakening of the foundations of the heavily laden troughs, partly by increase of area, wherewith to accommodate the accentuation of the trough formed and, partly, by rise in temperature induced in the lower layers of the deeply depressed mass of sediments. The strength of the superincumbent load of sediments is overcome by the reaction towards the surface—region of negligible pressure downwards—of the material underlying the base of the trough, because of lack of reinforcement, or bonding, in its structures as compared with the reinforcement in the structures of the associated stable land. In other words, the upward reaction of the heated subsurface material permits of the fusion and rise of rock to the surface along zones of definite structural weakness. Volcanic phenomena, at this stage, have become common in the geosyncline; there now ensues a transfer of material from the subsurface neighbouring regions to the progressively weakening geosynclinal mass. A geanticline grows in the geosynclinal area, and this becomes ornamented with explosive vents. As the geanticline spreads and rises in the weakening trough area, there ensue overfoldings and thrustings, which become correspondingly severe in proportion to the mass and thickness of the sediments affected and also to the height to which they have been raised. Compensation is secured by an undulatory rearrangement of subsurface material right round the Earth. This, the observer notes, is the demand for isostatic adjustment in all parts of the world. Allowance, necessarily, is to be made in this action for a temporary lag of full adjustment, by reason either of excessively local rigidity or of instability. In the stable areas, the undulatory movement of adjustment is relatively weak; within the more mobile, or unstable, areas the response is more pronounced quantitatively; there follows a general emergence of the land areas due, in part, to the increase of volume by local melting of subsurface material, and partly also by the temporary depression of borderlands, and by readjustments round the margins of the oceans, especially those with more basic and potentially fluid foundations. Until such time as the ruptured geosynclinal masses of sediments shall have become comparable—by folding, heating, and igneous intrusion—in strength with the associated areas of stability, the observer recognizes the high probability of recrudescences of mountain-making in these areas.

The undulatory transfer of material in the loaded geosynclinal area is peculiar. The sedimentary prism rises in part, or as a whole, as a compound undulation, which, on attaining a height and size which limit its capacity for existence as a coherent structure, flows out at its base and sides in all possible directions at which the resistance to its movement is least. Hence arise the complicated series of close foldings, overfoldings, and thrustings of sheet upon sheet of the rising

material over the more lateral and stable portions. These movements may be rapid, when judged by geological standards of time; nevertheless, the observer is impressed by their exceeding slowness of operation when measured by the ordinary human ideas of the passage of time. Mighty mountain chains rise not as by enchantment from the waves; the grand Alpine and Himalayan fronts subtend the same angles to the student to-day as they did to his ancestors prior to the dawn of civilization; to the mind untrained in geological lore, the mountain chains become "the everlasting hills", they become the very symbols of stability. The giant overthrustings with their associated phenomena, involving miles of differential movement, may appear, to the philosophic geologist, as but fleeting incidents in a spectacular Earth drama of short duration, nevertheless those same thrustings may well have passed unnoticed by the varied forms of life which actually peopled the pile itself in its ascent and in its outward growth. Floras and faunas may have seized upon it and flourished as it grew upward and outward, and new varieties or even species of animals and plants may have been evolved in response to the changing climatic conditions of the rising and spreading mass. Waifs and colonists from foreign cold regions seized upon the upper parts of the new-born elevations as they were formed. Isostatic adjustment kept pace, approximately, with the great general movement, so that a grand movement of close folding and overthrusting may well be but a passing incident in a broadly vertical, that is, undulatory, rise, thus harmonizing the observations of the compressive and vertical, or undulatory, schools of thought with regard to mountain origins. Periodic volcanic and seismic phenomena may well be the only marked outward and visible sign of the Titanic turmoil in the subsurface region. In these thrustings, the direction most favoured is that of the foreland, by reason of the main transfer of material from the less stable area of the borderland and the ocean.

At this stage he turns his attention to the condition of the sub-surface portions of the stable blocks; for example, the great forelands. The undulatory transfer of material meets with relatively great resistance by these masses, as stated earlier, the net result being that they are buoyed up as wide undulatory surfaces or shields, which yield, however, at various points of relative weakness to rupture by tension during the earlier and more vigorous stages of world-wide adjustment to topographic revolutions within the geosynclinal areas. This local rifting of the shields and sites of ancient orogenies leads to flooding of their surfaces with basic lavas or to their subsurface penetration by sills and related forms of intrusion. It is a significant fact that the rupture of these relatively stable blocks extends so deeply into the crust as to tap the more basic underlying material.

These observations suggest that mountain-making activities cannot be expected to be either strictly contemporaneous round the world, or to be confined to a single phase of folding and undulatory uplift. On the one hand, a geosynclinal area may be stabilized progressively, with gradual welding of one stable block to another, and, on the other hand, mountain-making activities may be delayed as compared with others in distant areas, during the same great period of topographic revolution, owing to the relative slowness in the loading of geosynclines, coupled with the variable strength of the force with which the subsurface activity reacts towards the surface.

It is apparent, moreover, to the observer, that the facts of Earth rotation, the omnipresent potentiality for immediate rock flowage and fusion which exists at relatively shallow depths in the crust, together with the associated state of chronic unstable equilibrium induced thus in the crust, all conspire to maintain revivals

of undulatory surface movement, but with decreasing strength until world conditions of greater surface stability are obtained. Such a condition of apparent stability, however, is quite deceptive, inasmuch as the subsurface material, at that stage, has passed merely from a stage of relatively rapid and repeated adjustments of equilibrium to a "still stand", as it were, of strained equilibrium, which only awaits an opportunity to break through afresh to the surface by the formation and loading of new troughs, which, in turn, implies the inevitable repetition of transfer of plastic and molten material from beneath the sinking floor of the trough to the feeding geanticline or borderland.

Retreating again to a distant position from the Earth, the observer perceives, during his flight through space, the various main stages of the structural history of Africa, Antarctica, and Peninsular India. These all are relatively stable structures which appear definitely to have grown, mainly, "in place" during pre-Cambrian time, by the gradual gathering to themselves of marginal mountain growths. Africa has added marginal growths of folded mountain ranges to its stable mass in the southern and north-western extremities during Palaeozoic and later time. North and South America, Asia, Europe, and Australia appear to have commenced as nuclei, wreathing themselves with mountain growths, and developing outer insular arcs or borderlands. As for later continental history, South America appears to be an ancient land around whose stable eastern mass folded mountains of post-Cambrian age have been wrapped, the ancient strip of western borderland having sunk in late geological time as a compensation for the Andean elevation. In North America, Europe and Asia, he notes the welding together of the ancient nuclei by means of the slow process of strengthening the depressed and mobile areas which once separated the nuclei from the ancient borderlands. In Europe he notes the definite influence of the stable block of Africa, and the more mobile area of the Palaeozoic Atlantic; in North America the mobile area of the Palaeozoic Atlantic and of the mobility within the Pacific from the pre-Cambrian right through to the present; in Asia, the influence of Africa, Arabia, India, the south-eastern massifs, and the Pacific on the east. In Australasia, he perceives a history somewhat similar to that of Asia during the Palaeozoic.

He concludes that the greater land masses and the ocean basins appear to have been permanent features which have suffered only a moderate amount of modification in form from some pre-Palaeozoic period.

Dr. G. A. Waterhouse, Honorary Treasurer, presented the balance-sheets for the year ended 28th February, 1938, duly signed by the Auditor, Mr. F. H. Rayment, F.C.A. (Aust.); and he moved that they be received and adopted, which was carried unanimously.

No nominations of other candidates having been received, the Chairman declared the following elections for the ensuing session to be duly made:

President: T. C. Roughley, B.Sc., F.R.Z.S.

Members of Council: E. C. Andrews, B.A., W. R. Browne, D.Sc., E. Cheel, A. G. Hamilton, F. H. Taylor, F.R.E.S., F.Z.S., A. R. Woodhill, B.Sc.Agr.

Auditor: F. H. Rayment, F.C.A. (Aust.).

A cordial vote of thanks to the retiring President was carried by acclamation.

Linnean Society of New South Wales.

GENERAL ACCOUNT. Balance Sheet at 28th February, 1938.

LIABILITIES.

	£ s. d.	£ s. d.
Capital: Amount received from Sir William Macleay during his lifetime	14,000 0 0	
Further sum bequeathed by his Will	6,000 0 0	
		20,000 0 0
Contingencies Reserve		9,287 9 1
Commercial Banking Co. of Sydney Ltd.		166 10 1
Income Account at 28th February, 1938		26 8 4
		£29,480 7 6

ASSETS.

	£ s. d.
Society's Freehold	11,000 0 0
Consols	500 0 0
Loans on Mortgage	2,500 0 0
Science House (one-third share)	14,590 0 0
Metrop. W.S. & D. Board Debentures	494 7 6
Rural Loan	386 0 0
Cash in hand	10 0 0
	£29,480 7 6

INCOME ACCOUNT. Year Ended 28th February, 1938.

	£ s. d.	£ s. d.
To Balance from 1936–37		209 9 4
„ Salaries		1,010 0 0
„ Printing Publications	422 9 11	
„ Illustrations	95 15 5	
		518 5 4
„ Rates and Insurance		186 18 7
„ Library		8 5 0
„ Postage	41 17 3	
„ Petty Cash	13 17 7	
		55 14 10
„ Audit	7 7 0	
„ Printing	22 0 2	
„ Attendance and Cleaning	45 6 0	
„ Expenses	24 14 4	
		99 7 6
„ Bank Expenses		0 10 5
„ Appropriation: Contingencies Reserve		29 8 0
„ Balance		26 8 4
		£2,144 7 4

	£ s. d.	£ s. d.
By Subscriptions: 1937–38	150 13 8	
Arrears	21 0 0	
In Advance	10 13 6	
Associate	0 10 0	
		182 17 2
„ Life Subscription		15 15 0
„ Entrance Fees		13 13 0
„ Interest		164 1 7
„ Rent		337 10 0
„ Science House		200 0 0
„ Sales (including 60 copies of PROCEEDINGS purchased by Government of New South Wales)		151 16 3
„ Fellowships Account (surplus income at 28th February, 1938, transferred)		761 11 2
„ Refund payments from Fellowships Capital		317 3 2
		£2,144 7 4

Examined and found correct. Securities produced.
F. H. RAYMENT, F.C.A. (Aust.),
Auditor.
11th March, 1938.

G. A. WATERHOUSE,
Hon. Treasurer.
7th March, 1938.

LINNEAN MACLEAY FELLOWSHIPS ACCOUNT.

BALANCE SHEET at 28th February, 1938.

LIABILITIES.	£	s.	d.	ASSETS.	£	s.	d.
Amount bequeathed by Sir William Macleay ..	35,000	0	0	Consols	11,400	0	0
Surplus Income Capitalized	15,182	14	8	Loans on Mortgage	38,030	9	11
				Rural Loan	477	10	0
				Commercial Banking Company of Sydney Ltd. ..	169	3	0
				Commonwealth Savings Bank	105	11	9
	£50,182	14	8		£50,182	14	8

INCOME ACCOUNT. Year Ended 28th February, 1938.

	£	s.	d.		£	s.	d.
To Salaries of Linnean Macleay Fellows	1,600	0	0	By Interest	2,375	14	2
„ Expenses	14	3	0				
„ General Account	761	11	2				
	£2,375	14	2		£2,375	14	2

Examined and found correct. Securities produced.
F. H. RAYMENT, F.C.A. (Aust.),
Auditor.
11th March, 1938.

G. A. WATERHOUSE,
Hon. Treasurer.
7th March, 1938.

BACTERIOLOGY ACCOUNT.

BALANCE SHEET at 28th February, 1938.

LIABILITIES.	£	s.	d.	ASSETS.	£	s.	d.	£	s.	d.
Amount bequeathed by Sir William Macleay	12,000	0	0	Consols				15,820	0	0
Accumulated Income Capitalized	3,820	0	0	Cash—						
Income Account at 28th February, 1938	536	11	5	Commercial Banking Company of Sydney Ltd.	300	16	3			
				Commonwealth Savings Bank	229	15	2			
				In hand	6	0	0			
								536	11	5
	£16,356	11	5					£16,356	11	5

INCOME ACCOUNT. Year Ended 28th February, 1938.

	£	s.	d.		£	s.	d.
To Salary	600	0	0	By Balance from 1936–37	534	12	7
„ Expenses	21	0	11	„ Interest	624	16	0
„ Petty Cash	1	16	3				
„ Balance to 1938–39	536	11	5				
	£1,159	8	7		£1,159	8	7

Examined and found correct. Securities produced.

F. H. RAYMENT, F.C.A. (Aust.),
Auditor.
11th March, 1938.

G. A. WATERHOUSE,
Hon. Treasurer.
7th March, 1938.

THE ECOLOGY OF THE CENTRAL COASTAL AREA OF NEW SOUTH WALES. II.

PLANT SUCCESSION ON THE HAWKESBURY SANDSTONE.

By Ilma M. Pidgeon, M.Sc., Linnean Macleay Fellow of the Society in Botany.*

(Plates i–iv; one Text-figure.)

[Read 30th March, 1938.]

Factors of the Habitat. Plant Succession: (1) Primary Succession, (*a*) Xeric Lithosere (Initial seral phases—Scrub—Tree-scrub—Low scrub-forest—Tall scrub-forest—High forest); (*b*) Moist Lithosere (Various types—Swamps). (2) Secondary Succession.

An account is given of plant succession and the plant communities on the Hawkesbury Sandstone area. Most of the detailed field observations were made on the Hornsby Plateau, but the sequence of communities is similar throughout the sandstone uplands of the central coastal area of New South Wales. Specific variations occur in different localities; for instance, there is a marked variation in the tree species controlled by altitude and latitude, but the differences in the floristic composition of the early seral communities are not marked. Unless otherwise stated, the species quoted are those typical of the Hornsby Plateau.

Previous accounts of the sandstone flora of the Sydney district have been floristic, e.g., Hamilton (1912, 1923, 1932) and Hamilton (1918). Osborn (1930) commented on the general features of the sandstone flora and reviewed and summarized our knowledge of the so-called xerophytic features of the sclerophylls (see also Wood, 1934). The sclerophyllous vegetation of the Hawkesbury Sandstone is characterized by hard, tough, dry leaves, and has developed under conditions of bright sunlight, exposure and ready drainage through a shallow soil of poor water-retaining capacity. Thick cuticle, numerous stomata, frequent veins and excess carbohydrate formation, leading to the development of thick-walled cells and a consequent hard internal skeleton of fibres, are signs of intense vegetative activity. The external conditions also favour a vigorous transpiration rate so long as water is available. The significance of the structure of the sclerophylls lies in the fact that high lignification prevents or delays any evidence of wilting. In this feature lies the chief difference between sclerophylls and mesophytes.

Factors of the Habitat.

The general physiographic, edaphic and climatic features of the Hornsby Plateau have already been referred to (Pidgeon, 1937). Here the habitat factors will be discussed in more detail.

Topography.—The topographical features of the Hornsby Plateau exert a marked influence on the vegetation. There are two extreme topographical habitats, the plateau surface and the gully. The plateau is much dissected; the slopes (Pl. iii, fig. 21) and gullies (Pl. iii, fig. 20) present more favourable habitats than the plateau surface. The angle of slope varies with the depth and extent of the

* The writer commenced this work in 1935 as Caird Scholar in Botany, and continued it in 1936 as Science Research Scholar of the University of Sydney.

valley. In a comparatively wide and shallow gully, the slope is gentle; the gorges are deep, narrow and precipitous; those cut by tributaries of the Hawkesbury River are up to 500 feet deep. Vertical rock cliffs often interrupt the steep slopes of these narrow ravines and here small waterfalls are of frequent occurrence.

Drainage.—Deficient drainage, induced by a series of comparatively level areas, results in the formation of swamps which are quite common on the surface of the plateau, and are less frequently represented as "hanging swamps" in the upper parts of valleys. Most of the surface and slope areas are efficiently drained, but the excessive drainage of many steep slopes is a notable feature.

Aspect.—The surface of the plateau is exposed to intense sunlight and strong wind action; the slopes are usually more sheltered. Aspect, i.e., the direction of the slope, determines the degree of protection from the desiccating westerly winds. A slope with a westerly, south-westerly or north-westerly aspect is comparatively rigorous. The effect of insolation can be estimated by a comparison of the plant communities on north-easterly slopes with those on south-easterly slopes. On northerly slopes, increased sun exposure, resulting in more rapid evaporation and transpiration, results in a relatively open type of plant community. On southerly slopes are found a number of species representing the mesophytic element in the sclerophyll formation. The most favourable slopes are those with an easterly, south-easterly or southerly aspect.

Soil.—(i) Depth. The sandy soils vary in depth from a few inches to several feet. On the coastal sandstone headlands and rocky escarpments, only a shallow layer of sandy soil is lodged in the crevices and depressions in the rocks (Pl. ii, fig. 17). Towards the rear of the headlands, and over the plateau surface and slopes, a fairly continuous soil cover is formed, but is interrupted by frequent outcrops of rock (Pl. ii, figs. 14, 16, 18). Although there may be only an average depth of a few inches in some habitats, the roots of trees penetrate the deeper pockets of soil amongst the underlying rocks. On the slopes, soil does not accumulate beyond a certain depth, even under the protective cover of vegetation. While the mobility of the soil varies with the slope, the frequent breaks of slope caused by outcropping rocks and loose boulders prevent excessive down-slope migration of soil particles. The soil removed from the slopes accumulates in valleys, where the soil is relatively deep. A soil cover of several feet develops on the gently sloping areas of portions of the valleys and uplands.

(ii) Humus Content.—The humus content of these sandstone soils is of particular importance since it compensates to some extent for the deficiency in colloidal constituents, and thus increases the water-retaining capacity which would otherwise be very low. As the occurrence of conditions which favour oxidative decomposition and humification varies considerably in different habitats, the quantity and kind of humus vary accordingly. In swamps, for example, the deficient drainage results in sufficiently permanent conditions of wetness to induce the formation of a peat-like soil by anaerobic humification.

Losses of organic material by aerobic decomposition must be considerable over much of the sandstone area. Two factors especially favour this process: (1) The good soil aeration resulting from the light sandy texture; (2) the slow and regular addition of plant residues, which do not lead to accumulation of litter, since the ever-green vegetation drops its leaves and twigs gradually throughout the year. In well-drained areas on the plateau, the intense sunlight and high rate of soil-moisture evaporation are additional conditions favouring oxidative decomposition. The prevalence of bushfires also reduces the amount of plant residues available for humification. Consequently the content of organic matter

in these soils is low, though the unchanged plant residues often form a dry litter. On more favourable habitats such as slopes and gullies, where temperatures are decreased and moisture increased, a considerable proportion of humification occurs. Bushfires are also less frequent here than on the uplands.

The amount of organic matter in the soil varies with the habitat. The humus may occur only in the upper layers, or may be homogeneously distributed throughout the entire depth. The soils in gullies contain a high percentage of humus and are often covered by an abundant litter of decaying vegetation several inches deep. This is the result not only of rapid humification, but of the accumulation of downwash from the slopes.

(iii) Stage of Development.—It must be emphasized that the youthful physiography of the Hornsby Plateau and Blue Mts. results in immature and shallow soils over most of these areas. In other sandstone localities, e.g., on parts of the southern plateau (Nepean Ramp), where the plateau is not so extensively dissected and where there are relatively large areas of undulating uplands, the soil has developed comparatively rapidly, so that now these areas are covered by a fairly deep, sandy, podsolized soil. On such uplands, the continuous effect of downwardly percolating water results in the leaching of soluble constituents and the rotting of the underlying rock.

On the Hornsby plateau, the extreme dissection results in the exposure of a considerable amount of sandstone rock. Soil development over much of the area proceeds comparatively slowly, owing to the fact that the steep slopes result in excessive drainage, and the run-off water also removes a large number of soil particles. Wind is another effective agent in retarding the accumulation of soil in exposed areas.

The leaching of iron in the zonal development of these shallow soils is very marked. Frequently, where their content of organic matter is low, the zonal development is limited to an iron staining of the B horizon. This profile is typical of scrub-forest soils on the uplands, ridges and slopes. A completely podsolized soil is more characteristic of the deeper soils of the gentle valley slopes and limited patches of unbroken upland. Soils which are dark in colour due to the homogeneous distribution of organic matter, frequently occur in pockets on steep slopes, and also characterize the floors of many gullies. Such soils have a good water-retaining capacity.

Plant Succession.

The Hawkesbury Sandstone country is covered by a mosaic of plant communities of various scrub-forests, broken by low scrub and swamp in the less favourable areas, and by high forest and patches of mesophytic vegetation in the more favourable areas. These communities have been referred to previously and, with the exception of the mesophytic element, form part of the Mixed *Eucalyptus* Forest Association (Pidgeon, 1937). The occurrence of such a mosaic of communities over the sandstone area suggests the necessity for a study of plant succession (Clements, 1916), in order to elucidate their relationships.

The seral stages from pioneer to climax are not set out in lateral sequence here as they are in hydroseres and psammoseres, so that the sequence of communities is very much more complicated. The early stages of colonization are very prolonged. The pioneer stages may be seen on rock outcrops scattered throughout the more advanced communities. The most prominent colonizers on rock surfaces are crustaceous lichens. These are succeeded by foliose and fruticose lichens, mosses, and higher life-forms such as herbs and shrubs, the incidence of

which is consequent upon the progressive improvement of the habitat. Finally a sclerophyll forest is developed, with under-shrubs becoming subdominant. Throughout the sandstone area the general trend of succession is towards a high-forest community, high forest being the typical expression of the climax *Eucalyptus* Forest Formation. However, the sere is arrested at various stages of development by local unfavourable habitat conditions, so that the climatic climax is not extensively developed. These advanced seral communities are recognized as scrub, tree-scrub, low scrub-forest and tall scrub-forest, which will be described fully in the text.

1. PRIMARY SUCCESSION.

In the Hawkesbury sandstone the rock is normally extremely deficient in water, but owing to local seepage or inadequate drainage some rocks are moist. In such moist habitats, the succession is either characterized by a less xeric flora, or, in extreme cases, the sere is markedly deflected and culminates in a swamp.

The primary succession will be discussed as (*a*) xeric and (*b*) moist lithoseres.*

(*a*) *Xeric Lithosere.*

Initial Seral Phases.

Algae, crustaceous lichens, foliose lichens, xeric mosses and fruticose lichens, hemicryptophytes and shrubs form communities which comprise the initial seral phases of the xeric lithosere.

Algae.—The pioneers of the xeric lithosere are blue-green algae including species of *Stigonema* and *Gloeocapsa* which form microscopic colonies over the entire rock surface. *Trentepohlia* spp. have also been recorded and are particularly abundant at high altitudes (e.g., on the Blue Mts. and Robertson Plateaux) in fairly humid situations where they give the rocks a rust-coloured appearance.

Crustaceous Lichens.—On the dry exposed sandstone surfaces various crustaceous lichens are the typical macroscopic pioneers. Since they are partly embedded in the rock substratum, they assist climatic weathering, etching and pitting the rock by chemical means. These lichens form colonies composed of many individuals each growing centrifugally. The rock surface may become almost entirely encrusted (Pl. i, fig. 1).

Foliose Lichens.—The crustaceous lichens, together with the disintegrated rock, form a suitable substratum for the development of foliose lichens (Pl. i, figs. 2, 3), whose expanding thalli cut off the light from the crustaceous forms and eventually replace them. The foliose lichens are especially abundant where the rock surface is rough and pitted; here the previous stages are apparently of short duration. These lichens, with their spreading leaf-like expansions of many lobes, offer more opportunities for the absorption of water, accumulation of humus, dust, and air-borne spores and also lessen evaporation. This leads to a distinct change in the habitat and to the accumulation of a small amount of disintegrated rock and organic matter from lichen residues.

Xeric Mosses and Fruticose Lichens are higher in life form and stature than the foliose lichens, and may occur intermingled or in pure communities, frequently forming dense mats. They usually become established where the foliose lichens have already prepared the way for their development (Pl. i, fig. 3).

* Lithosere is a succession initiated on bare rock. Xeric lithosere refers to dry rock succession, and moist lithosere to succession on rocks which are either intermittently or constantly moist, but never covered by water.

The xeric mosses play a more important part in succession than do the fruticose lichens. They form extensive mats over the rock surfaces (Pl. i, fig. 7; ii, fig. 13) and are a collecting ground for wind or water-borne particles. Their rhizoids penetrate the loosened sandstone and cause further disintegration. By this process and by the accumulation of their older parts as they die, the mosses form a coarse, sandy, humus soil often held to a depth of two or three inches.

Through the activity of these xeric mosses and fruticose lichens, the habitat becomes considerably modified as regards light, moisture, temperature and soil, permitting the invasion of higher life forms into the community.

Hemicryptophytes.—Species of a hemicryptophytic nature may then become established and tend to supplant the original colonizers, which, in reacting on the environment, produce conditions more or less unfavourable to themselves. These new invaders are typically *Lepyrodia scariosa* and *Schoenus deustus*. At first these are widely spaced, but they increase by vegetative propagation and further migration, and form clumps throughout the moss mats (Pl. i, fig. 8; ii, fig. 13). Other hemicryptophytic species which may become established at this stage are *Lomandra longifolia*, *Dianella coerulea* and *Lepidosperma laterale* (Pl. i, fig. 9; ii, fig. 13). The herb, *Crassula Sieberi*, may also occur.

Further biotic reactions accompany this change in the floristic composition of the community. The matted roots assist in rock disintegration, and the decaying residues increase the humus content. As well as increasing soil depth the new invaders afford shade to the soil, lessening evaporation and temperature extremes. The habitat, becoming less xeric, is then open to invasion by shrubs.

Shrubs.—These new invaders are low shrub species such as *Epacris pulchella*, *E. microphylla*, *Leptospermum scoparium*, *Leucopogon microphylla* and *Darwinia fascicularis*. These are usually the pioneer and dominant shrub species, but any of the following may also be important: *Pultenaea elliptica*, *Bossiaea scolopendria*, *Hakea* spp. and *Grevillea* spp.

The conditions which permit the growth and development of shrubs, together with the consequent diminution in light intensity, are unfavourable to pioneer xeric mosses, which are unable to withstand this competition.

Any shrub species typical of the sandstone flora is capable of establishment at this stage, but the species mentioned occur fairly constantly, particularly those of the first group. These shrubs are typically shallow-rooting species, capable of growth in soil of limited depth. The variation in the species of seedlings suggests that chance migration plays a big part. All, or almost all, the pioneer shrub species belong to the Nanophanerophyte life-form class and to the leptophyll leaf-size class.

At first, the shrub seedlings are widely spaced. Some individuals are unable to survive this primary period of colonization. After establishment of the first seedling invaders, there is a rapid increase in the number of similar small shrubs, due to simple aggregation of germules around the parent, and migration from adjacent populations. Thus the community progresses from an open to a closed one.

By the invasion of other hemicryptophytes, a few chamaephytes and many nanophanerophytic herbs and woody shrubs, all the available surface is eventually occupied by plants, and competition is initiated. There is not sufficient moisture, light or space for all the individuals, so the final grouping of the species in any one area depends on establishment and competition.

This shrub-phase grades imperceptibly into a scrub community (Pl. i, fig. 9).

Special Types of Succession.—The initial stages of the sere, as described above, are often seen in lateral sequence on flat rock surfaces and ledges, surrounded by scrub or forest (Pl. i, fig. 9; ii, fig. 13). Less commonly, the pioneer phases of the sere occupy depressions or pans on flat, extensive sandstone outcrops (Pl. ii, fig. 12). In these depressions water collects and hastens disintegration, and the lichen stage is rapidly succeeded by the moss community, in which the following hemicryptophytes become established: *Lepyrodia scariosa*, *Schoenus deustus*, *S. imberbis*, *Lepidosperma laterale*, *Lomandra longifolia* and *Dianella coerulea*. These are closely followed by the leptophyllous and nanophyllous shrubs. These areas form small isolated "vegetation islands" in the rock outcrops.

In crevices in the sandstone formed by weathering along joints where conditions of exposure, water relations and micro-climate are more favourable, the early seral stages of succession, although practically identical with those already described, are much more rapid. Consequently the crevices are usually well vegetated while the surrounding rocks are still encrusted with lichens (Pl. i, figs. 10, 11; ii, fig. 17). Herbs and shrubs typical of these crevices are: *Lomandra longifolia*, *Xanthorrhoea hastilis*, *Lepidosperma laterale*, *Dianella coerulea*, *Epacris longiflora*, and less commonly *Schizaea bifida*.

Foliose and fruticose lichens and xeric mosses are probably able to colonize the weathered rock particles which sometimes accumulate in small quantities in tiny crevices or depressions in the rocks.

On any extensive rock surface, several centres of colonization by mosses and higher types may be seen, as well as the usual incrustation of lichens (Pl. i, figs. 4, 6). The crevice and rock-pan communities remain fairly stable for some time, the sere being arrested until the surrounding rock becomes weathered and ultimately occupied by a shrubby vegetation, which coalesces with the initial centres of colonization.

The most notable feature of the variations in the initial seral stages described above appears to be the elimination or reduction in the period of dominance of the lichen stage, a short cut which emphasizes the fact that climatic weathering, acting apart from the biological environment, is very important in the early stages of soil formation.

Where vertical rock faces of ledges or large loose boulders are colonized, succession cannot progress very far. The lichen-encrusted rock-faces are ultimately occupied by a number of separate or co-extensive mat-like colonies of mosses and fruticose lichens (Pl. i, fig. 4) with the climbing fern *Cyclophorus serpens* (Pl. i, fig. 6). Xeric rock orchids are usually conspicuous in these habitats, the most typical species being *Dendrobium linguiforme*, *D. speciosum* and *D. striolatum* (Pl. i, fig. 5). In moister and more shady areas this lithophytic flora is much more varied (see below).

Interrelations of Initial Phases.—As the vegetation develops, a series of invasions leads to a rise and fall of successive plant communities as each stage modifies the environment. Although the individual species are not always constant in their occurrence, each stage in the sere may be interpreted on the basis of progressive life-forms. The lichen stage is replaced by the moss, hemicryptophyte, and nanophanerophyte or shrub phases in regular sequence.

As an example of the changes in habitat which result from this succession of plant communities, an analysis indicating changes in two of the soil properties is summarized in Table 1. This analysis is from two typical examples (*a* and *b*) of the pioneer phases arranged in lateral sequence on a flat rock surface.

TABLE 1.

Seral Stage.	Nature of Soil.	Soil Depth (Inches)	Percentage Water-Retaining Capacity.	Percentage Loss on Ignition.
——	Crushed sandstone	—	*a* 25 *b* 24	1·5 1·4
Foliose lichen community..	Disintegrated rock and lichen residues	—	*a* 41 *b* 39	11·0 10·5
Xerophytic moss community	Humus and sand	½	*a* 77 *b* 63	18·0 11·0
Moss and hemicryptophyte (*Lepyrodia scariosa*) ..	Humus and sand	3	*a* 53 *b* 52	13·0 18·0
Shrubs and hemicryptophytes	Top layer of humus with small amount of sand .. .. Sand and small amount of humus	At 1 inch at 4–5	*a* 42 *b* 47 *a* 37 *b* 28	9·5 7·1 4·5 2·9
Scrub	Sandy with small amount of humus .. .. Sand	at 1–3 at 6	*a* 28 *b* 32 *a* 26 *b* 25	3·5 3·4 1·5 1·9

The first-formed soil contains a large amount of humus from the lichen and moss-plant residues. As the sandstone disintegrates, the percentage of sand increases, and the water-retaining capacity decreases.

Scrub.

Physiognomic Structure and General Features.—This well-defined seral community succeeds the shrub phase and persists over a considerable area of the uplands (Pl. ii, fig. 14). The scrub is composed almost wholly of sclerophyllous evergreen woody shrubs forming a dense tangle of vegetation (Pl. ii, fig. 15).

The most frequent leaf-size classes are the leptophylls and nanophylls with a few microphyllous forms. The dominant life form is the nanophanerophyte; hemicryptophytes are frequent and chamaephytes rare. Most of the species are perennial, but some grasses, orchids and a few of the Liliaceae show a marked seasonal development. Herbs and grasses are relatively unimportant, and much of the actual surface of the ground is bare.

The height of any particular scrub community depends on the degree of exposure. In low scrub, the shrubs, interpenetrated by herbs, form a fairly continuous layer less than 3 feet high. In taller scrub, which varies from 3 to 10 feet high, two shrub strata may be recognized (Pl. ii, fig. 15). The tall shrub stratum usually averages about 6 feet, while the low shrub stratum attains a general level of about 2 or 3 feet.

A special development of low scrub occurs on the coastal headlands where the severe exposure to winds gives the scrub a different facies. The vegetation

is low and closely packed where there is a continuous soil cover (Pl. ii, fig. 16), but on the rocky parts of the headlands and frontal ledges a more open type of community prevails; nanism is illustrated by the typical rosette (Pl. ii, fig. 17), prostrate or matted habit of the species which have an average height of eighteen inches to two feet. Many shrubs which are normally erect assume a laterally spreading form, with numerous, short, twiggy stems. The severe exposure results in the diminution and toughening of the foliage, as well as causing nanism.

Floristic Structure.—The scrub exhibits great wealth of species, and a notable lack of uniformity in the distribution of species, not only in any particular locality, but over a wide area. A plant which is common or dominant in one area may be subordinate or rare some few hundred yards away. The total absence of some species over several miles of country is not uncommon. *Pultenaea stipularis*, *Eriostemon Croweii* and *Ricinocarpus pinifolius*, for example, are absent from the Pennant Hills district (3 miles SW of Hornsby), though common elsewhere. The distribution of species even within a small area may be very difficult to explain. Co-dominance of many species exhibiting a highly integrated type of social growth is most frequent, although local dominance of one species does occur in some areas. The occurrence of locally dominant or common species cannot always be correlated with a particular ecological habitat. Some examples of correlation have, however, been observed, e.g., *Casuarina rigida* favours exposed rocky ridges, and *Hakea pugioniformis* flourishes in moist situations. In general, observations point to the haphazard distribution of species throughout the area. Modifications may occur in any one area as a result of fire, which may considerably influence distribution (cf. Jarrett & Petrie, 1929). After pyric denudation, many of the sclerophyllous species survive by means of resistant seeds or fruits, either attached to the parent plants or lying in the soil at the time of the fire. The ash and surface litter provide a suitable bed for their germination. Since seed dispersal and ripening occur at different periods of the year in different species, the aggregant or migrant species which become established vary considerably according to the time of occurrence of the fire. For example, if a subordinate shrub happened to be bearing ripe seed at the time of the fire and a large percentage of these survived destruction, the consequent seedling population might result in the locally dominant establishment of this particular species in the denuded area. However, the seed survival of many different species may be considerable, in which case local dominance does not occur. In any case, species whose seedlings become successfully established early after fires replace those species which do not survive.

After damage by fire, many woody plants are capable of regeneration by epicormic shoots, e.g., *Eucalyptus* spp. (Pl. iv, fig. 32), *Angophora cordifolia* and *Banksia serrata*. These species, and others, are also characterized by a renascent swollen stem occurring in a hypogeous position. Regeneration may also take place from root stocks which lie just beneath the ground, as in *Petrophila pulchella*. Only the parts of annually renascent geophytic herbs and rhizome-geophytes which are above the soil surface are usually destroyed, so that the underground organs of propagation rapidly produce new aerial shoots. Since the endemic flora is particularly rich in types capable of regeneration after fire, there is a tendency for the scrub flora to have much the same floristic composition after as before pyric denudation. The renascent types, being already well established, have the advantage over migrant or aggregant seedlings, so that usually only a small proportion of the latter persist. Only in localized areas where competition is not severe is it possible for dense communities of post-pyric seedlings to mature.

Floristic Composition.—Floristically, two phases of the same structural scrub are recognizable; (1) "dry" scrub, and (2) "moist" scrub.

The moist scrub is so called because of the intermittently moist conditions of the soil, due to poor drainage, but the soils are sandy and not "peaty". The moist phase of the scrub may be recognized by the dominance of "moisture preferring" species, many of which are also characteristic of shrub swamps on peaty soil, and others which flourish equally well in dry scrub (see Appendix, Table 1). The moist and dry phases of the scrub exist side by side often passing imperceptibly into one another.

The scrub flora is complex and variable, but a statistical analysis by means of quadrats has not been attempted.

Floristic lists in this paper have been compiled from many localities on the Hornsby Plateau. They include the most typical species, but are not exhaustive. The frequency values, given for individual species in the different strata, have been estimated by direct observation, and are therefore only approximate.

Of the species typical of the coastal sandstone headlands, only a few are practically restricted to the sea coast. Of these, *Westringia rosmariniformis*, *Eriostemon buxifolius*, *Leptospermum laevigatum* and *Pseudanthus orientalis* are the most important. The others are similar to those occurring elsewhere on the sandstone soil, although the number of species present is less and there is a marked tendency to the predominance of the hardiest sclerophylls. These include the cladode types, *Casuarina rigida* and *Bossiaea scolopendria*, the needle-leaved types, e.g., *Hakea gibbosa* and *H. pugioniformis*, and species with harsh tough-textured leaves belonging to the leptophyll leaf-size class of which the most prominent are *Banksia ericifolia*, *Kunzea capitata*, *Epacris microphylla*, *Leucopogon microphylla*, *Pultenaea elliptica*, *Dillwynia floribunda*, *Phyllota phylicoides*, *Philotheca australis*, *Calycothrix tetragona*, *Darwinia fascicularis*, *Hemigenia purpurea*, *Micrantheum ericoides* and *Leptospermum arachnoideum*. Some of the most typical herbs are *Lepidosperma laterale*, *Lepyrodia scariosa*, *Hypolaena fastigiata*, *Patersonia sericea*, *Lomandra obliqua*, *Restio fastigiatus* and *Xanthorrhoea hastilis*. Most of these are tussock-like in habit and offer little resistance to wind.

In the moist scrub, the following shrubs are typical: *Hakea pugioniformis*, *Persoonia lanceolata*, *P. salicina*, *Dillwynia floribunda*, *Aotus villosa*, *Angophora cordifolia*, *Leptospermum stellatum*, *L. scoparium*, *L. lanigerum*, *Epacris microphylla*, *Banksia ericifolia*, *Banksia latifolia* var. *minor* and *Viminaria denudata*. The characteristic herbs include *Costularia paludosa*, *Schoenus villosus*, *Xanthorrhoea hastilis*, *Actinotus minor*, *Dampiera stricta*, *Hypolaena fastigiata*, *Lepidosperma flexuosum*, *Schoenus deustus* and *Lepyrodia scariosa*.

A more complete list of the species occurring in this community is given in the Appendix, Table 1.

Factors Influencing the Distribution of Scrub.—The scrub flora is a community of plants growing under conditions rendered unfavourable for the development of forest by certain topographical features. On the uplands, as a result of inefficient drainage and fairly rigorous conditions of exposure, the scrub often persists as the moist phase. On plateau ridges or coastal headlands, severe exposure to strong westerly or onshore winds associated with shallow soil conditions results in the persistence of dry scrub.

Strong and constant winds are most important as agents increasing the rate of transpiration of plants. In exposed situations the taller the plant the greater

Floristic Composition of Dry Scrub.

SHRUBS.*

Common.

†*Banksia ericifolia* Linn.
Grevillea punicea R.Br.
†*Hakea acicularis* R.Br.
†*H. dactyloides* Cav.
Isopogon anemonifolius R.Br.
I. anethifolius R.Br.
†*Lambertia formosa* Sm.
†*Persoonia lanceolata* Andr.
Petrophila pulchella R.Br.
Bossiaea heterophylla Vent.
B. ensata Sieb.
B. scolopendria Sm.
Dillwynia ericifolia Sm.
†*Pultenaea elliptica* Sm.
Pimelea linifolia Sm.
Darwinia fascicularis Rudge.
Kunzea capitata Reichb.
Leptospermum arachnoideum Sm.
†*L. scoparium* Forst.
Brachyloma daphnoides Benth.
Epacris microphylla R.Br.
E. pulchella Cav.
Leucopogon microphylla Spreng.
Styphelia triflora Andr.

Locally Common.

†*Casuarina rigida* Miq.
†*Grevillea Caleyi* R.Br.
†*Acacia discolor* Willd.
A. myrtifolia Willd.
Ricinocarpus pinifolius Desf.
†*Lasiopetalum ferrugineum* Sm.
†*Angophora cordifolia* Cav.
Calycothrix tetragona Labill.
†*Kunzea corifolia* Reichb.
Micromyrtus microphylla Benth.
Epacris longiflora Cav.
Leucopogon ericoides R.Br.
Monotoca scoparia R.Br.
Woollsia pungens F.v.M.

Occasional.

†*Banksia aemula* R.Br.
†*B. serrata* Linn.
†*Hakea pugioniformis* Cav.
Lomatia silaifolia R.Br.
Conospermum ellipticum Sm.
C. ericifolium Sm.
C. longifolium Sm.
C. taxifolium Sm.
Grevillea buxifolia R.Br.
G. sericea R.Br.
†*Hakea gibbosa* Cav.
†*H. propinqua* Cunn.
Persoonia salicina Pers.
Acacia juniperina Willd.
A. suaveolens Willd.
Bossiaea microphylla Sm.
Mirbelia reticulata Sm.
Phyllota phylicoides Benth.
Boronia pinnata Sm.
B. ledifolia Gay.
Eriostemon hispidulus Sieb.
Philotheca australis Rudge.
Zieria pilosa Rudge.
Tetratheca ericifolia Sm.
T. juncea Sm.
Comesperma ericinum DC.
C. retusum Labill.
Phyllanthus thymoides Sieb.
Amperea spartioides Brongn.
Micrantheum ericoides Desf.
Hibbertia stricta R.Br.
H. fasciculata R.Br.
Styphelia longifolia R.Br.
S. tubiflora Sm.
Hemigenia purpurea R.Br.
†*Leptospermum stellatum* Cav.

Rare.

Banksia latifolia var. *minor* Maiden and Camfield.
†*B. spinulosa* Sm.
†*Persoonia ferruginea* Sm.
Acacia linifolia Willd.
†*Oxylobium trilobatum* Benth.
Dillwynia floribunda Sm.
Pultenaea daphnoides Wendl.
P. polifolia A. Cunn.
P. stipularis Sm.
Correa speciosa Andr.
Eriostemon Crowei F.v.M.
E. lanceolatus Gaertn.
Trachymene linearis Spreng.
Leucopogon esquamatus R.Br.
Lissanthe strigosa R.Br.
Chloanthes stoechadis R.Br.

HERBS AND GROUND FLORA.

Common.

Schoenus deustus F.v.M.
Lepyrodia scariosa R.Br.
Lepidosperma laterale R.Br.
Lomandra longifolia Labill.
L. obliqua Macbride.
L. glauca Ewart.
Dianella coerulea Sims.

Locally Common.

Caustis flexuosa R.Br.
C. pentandra R.Br.
C. recurvata Spreng.
Hypolaena fastigiata R.Br.
Restio fastigiatus R.Br.
Xanthorrhoea hastilis R.Br.
Burchardia umbellata R.Br.
Stypandra caespitosa R.Br.
S. umbellata R.Br.
Actinotus minor DC.
Mitrasacme polymorpha R.Br.
Dampiera stricta R.Br.
Candollea linearis F.v.M.

Occasional.

Themeda australis Stapf.
Lepidosperma filiforme Labill.
L. flexuosum R.Br.
Schoenus ericetorum R.Br.
S. turbinatus Poir.
S. villosus R.Br.
Lomandra filiformis Britten.
L. multiflora Britten.
Caesia parviflora R.Br.
Thysanotus junceus R.Br.
Haemodorum teretifolium R.Br.
Patersonia glabrata R.Br.
P. sericea R.Br.
Thelymitra ixioides Swartz.
Hovea heterophylla Cunn.
H. linearis R.Br.
Hybanthus filiformis F.v.M.
Halorrhagis teucrioides P.DC.
Actinotus Helianthi Labill.
Xanthosia pilosa Rudge.
Lobelia dentata Cav.
L. gracilis Andr.
Goodenia hederacea Sm.
Scaevola hispida Cav.
Dampiera Brownii F.v.M.
Candollea serrulata Labill.
Poranthera ericifolia Rudge.
Crassula Sieberi Druce.
Opercularia hispida Spreng.
O. aspera Gaertn.

* Owing to their variable habit, the shrubs cannot be classified according to occurrence in the tall or low shrub strata.
† Usually occurring in the tall shrub stratum.

the transpiration rate, as wind velocity increases with height above the ground. Combined with the frequently occurring water shortages due to the sandy soil this results in the stunting of the plants. The scrub therefore is characterized by a general vegetation level, the height of which varies with the severity of exposure. This accounts for the development of tall and low scrubs in different situations, and the extreme nanism of the plants of exposed headlands. Although this sclerophyllous flora can exist on a water deficit for considerable periods, a certain balance is established between the height of the vegetation and the amount of water regularly available.

Under similar climatic conditions, the water reserve in soils such as clays and loams, which have a high water-retaining capacity, is often sufficient for the development of forest, but on the sandstone, the combined effect of exposure and unfavourable soil conditions arrests the further development of the sere.

Tree-Scrub.

The Tree-Scrub is a transition community between the Scrub and the Scrub-Forest. It occupies a slightly less exposed habitat than that of scrub, although the soil conditions may be identical. Tree-Scrub is, in effect, a scrub community with scattered, stunted trees of *Eucalyptus haemastoma* Sm. and *E. gummifera* Gaertn. These are the hardiest of the species of *Eucalyptus* found in the area studied; *E. haemastoma* is found in the most exposed habitats. The trees give a certain character to this community, but can hardly be described as dominant, as they occur in local patches or as scattered individuals.

Occurring with the Eucalypts, but not so prominent, *Banksia ericifolia* and *Casuarina rigida* assume the dimensions of bushy trees. *Banksia serrata* is more rarely present.

On partially weathered rock outcrops, usually in exposed situations, *Casuarina rigida* or *C. suberosa* often forms an almost pure and dense thicket, 15–20 feet high, in which a few of the hardiest hemicryptophytes and sclerophyllous shrubs also occur. Such a stand may be regarded as a specialized type of tree-scrub.

When the trees exceed the general vegetation level, they are exposed to a greatly increased wind action, which may limit their further growth. In this case, the tree-scrub remains relatively static, the trees just exceeding the general level of the scrub, or extending up to about 15 feet in height according to the degree of exposure.

Mallee Scrub.—Several species of *Eucalyptus* in the area studied have a dwarf or mallee habit and occasionally form small patches of what may be termed mallee scrub. On the Hornsby Plateau, mallee scrub occurs on cool sandstone slopes, usually just below the ridges, and prefers the highest localities. Its distribution here is very limited, but is much more extensive on the Blue Mts. These patches of vegetation may be regarded in the same category as tree-scrub.

The most important mallee on the Hornsby Plateau is *E. virgata* Sieb., which attains a height of 6 to 20 feet; less prominent species are *E. Camfieldi* Maiden, *E. multicaulis* Blakely, and *E. obtusiflora* DC.

Low Scrub-Forest.

Distribution.—Scrub-forests occur on parts of the uplands protected from the full force of the winds. A conspicuous example of this is the presence of scrub-forests in small protected depressions or pockets on wind-swept surfaces. All westerly-facing slopes and ridges on the plateau are not occupied by scrub, since many of them are partially protected from the westerly wind by higher ridges,

allowing the development of a low scrub-forest. This forest characterizes a large proportion of the surface of the plateau (Pl. ii, fig. 18). This type of community also occurs on steep, upper, rocky slopes of valleys where soil is unable to accumulate to any great depth. Low scrub-forest is particularly characteristic of the upper north-west gully slopes in exposed areas; in contrast to this the upper south-east slopes are covered by a tall scrub-forest.

Structure and Floristic Composition.—Low scrub-forest differs from scrub in the presence of a definite tree stratum. It is an open community in which the trees are fairly widely spaced, and attain an average height of about 30 feet, although taller ones do occur. The most important trees are *E. haemastoma*, *E. gummifera*, *E. punctata*, *E. micrantha*, *E. Sieberiana*, *E. oblonga* and *E. eximia*. Their distribution varies with the habitat; all the species are not present in the one stand.

Smaller trees about 10–15 feet high are scattered throughout the community. Most important and widely distributed is *Banksia serrata*; *Angophora Bakeri* is locally abundant. *Banksia ericifolia* frequently occurs as a bushy tree, and *B. aemula*, *B. marginata*, *Casuarina suberosa*, and *Xylomelum pyriforme* may also occur. In addition, local thickets of young saplings of *Eucalyptus* spp. often give a definite character to this irregular stratum.

Owing to the spacing of the trees and their open foliage, sunlight is not prevented from penetrating to the ground. There is consequently a well developed shrub stratum. The shrubs are irregular in their distribution, and do not always form a continuous layer, although their growth is typically dense. They vary in height from 2 to 6 feet, although occasional individuals in open situations may attain a height of 10 feet (e.g., *Hakea* spp., *Leptospermum* spp.). An under layer of small shrubs and herbs is typically present.

The shrubs are sclerophyllous and consist mainly of the same species as the scrub flora. There are few or no additional species, although many of the typical scrub species are not so abundant, or may be absent, e.g., species of *Restio*, *Leptocarpus*, *Caustis*, *Lepidosperma* and *Hypolaena fastigiata*. This is possibly due to the reduction in the light intensity. (See appendix, Table 2.)

A variation of the low scrub-forest occurs in rather limited patches on the uplands, which are fairly sheltered but poorly drained (Pl. 2, fig. 19). The soils are often sands about 2–3 feet deep. The undershrubs are not strongly developed as a stratum, attaining an average height of only 2 feet, and do not impart any distinctive character to this community.

E. micrantha, *E. gummifera* and *E. capitellata* are the most important trees. The undergrowth includes the following species indicative of a moist habitat: *Banksia latifolia* var. *minor*, *Bauera rubioides*, *Pimelea linifolia*, *Epacris obtusifolia*, *Actinotus minor*, *Mitrasacme polymorpha*, *Dampiera stricta*, *Sowerbaea juncea*, *Goodenia bellidifolia*, *Costularia paludosa*, *Restio complanatus*, *Leptocarpus tenax* and *Selaginella uliginosa*. Larger plants such as *Hakea pugioniformis*, *Persoonia salicina* and *Xanthorrhoea hastilis* occur as scattered individuals.

Tall Scrub-Forest.

Structure and Distribution.—The tall and low scrub-forests have certain structural affinities. The difference lies chiefly in the height of the tree stratum which alters the appearance. There is usually a closer spacing of the dominant trees in the tall scrub-forest than in the low scrub-forest. The average height of the trees in the tall scrub-forest is 50–60 feet. Smaller trees may also be present

and attain a height of 20 feet or more. The undershrubs vary considerably in distribution and type.

This forest community is extensively developed on the slopes and in gullies, where conditions of shelter and soil moisture are favourable. It also occupies areas on the uplands (Pl. 3, fig. 21) where exposure is not too rigorous and where soil has accumulated to a considerable depth.

The tall scrub-forest is discussed in this paper as a structural entity for convenience, and in order to indicate its position in succession. It cannot be too strongly emphasized, however, that this community is one of the most variable, both structurally and floristically, owing to its development in a variety of habitats.

Floristic Composition.—Only a brief review of the floristic composition of the forests, so far as is necessary to indicate succession, is given here.

Eucalyptus piperita and *Angophora lanceolata* are the most characteristic trees of this community, and frequently occur as co-dominants. *E. gummifera* has a wide range of habitats, and is an important member of both tall and low scrub-forests. *E. punctata*, *E. Sieberiana* and *E. umbra* are subordinate species. *Angophora intermedia* and *Casuarina torulosa* are dominant species in restricted localities. *E. pilularis*, in association with *E. piperita* or *Angophora lanceolata* or both, represents a link between the tall scrub-forest and high forest. *E. pilularis* has a very limited distribution on sandstone soils, occurring only in gullies where soil depth and soil moisture conditions are the most favourable.

As in the low scrub-forest, smaller trees occur scattered throughout the community. *Banksia serrata* and *Casuarina suberosa* are common, but in the most favourable areas these are replaced by *Casuarina torulosa*, *Acacia longifolia* and *Persoonia linearis*.

The distribution of the undergrowth varies considerably with changes in topography. On steep slopes, with abundant rocky outcrops, the under-shrubs do not form a continuous layer; there is a scattered assemblage of tall and small shrubs usually not exceeding 6 feet in height, and often much less. On portions of the uplands and gentle northerly slopes, i.e., in habitats receiving direct insolation, there is an open spacing of the trees and a dense development of the undergrowth. Two fairly continuous shrub layers are often recognizable, attaining an average height of about 2 and 6 feet respectively.

The shrubs of the tall scrub-forest have a definitely sclerophyllous facies. Many characteristic scrub species occur, e.g., *Hakea dactyloides* and *Persoonia lanceolata*; some are much more common, e.g., *Trachymene linearis* and *Pultenaea stipularis*, whilst others are less abundant. Different species of the same genus are characteristic of the scrub and forest communities; for example, in the forest *Leucopogon lanceolatus* is more frequent than *L. microphylla*, *Bossiaea microphylla* than *B. scolopendria*, *Pultenaea stipularis* and *P. daphnoides* than *P. elliptica*, *Leptospermum flavescens* than *L. scoparium* and *Xanthorrhoea arborea* than *X. hastilis*. Other under-shrubs which occur in forest communities make their appearance for the first time, e.g., species of *Phebalium*, *Olearia* and *Cassinia*. (See appendix, Table 2.)

The composition of the shrub stratum varies with the habitat. Shrub species typical of the tall scrub-forest as a whole include: *Persoonia lanceolata*, *P. salicina*, *P. pinifolia*, *Hakea dactyloides*, *Banksia spinulosa*, *Pultenaea daphnoides*, *P. stipularis*, *Trachymene linearis*, *Leucopogon lanceolatus*, *L. amplexicaulis*, *Bossiaea microphylla*, *Dillwynia ericifolia*, *Acacia discolor*, *A. myrtifolia*, *A. linifolia*, *Platylobium formosum*, *Eriostemon Crowei*, *Lomatia silaifolia*, *Cassinia*

denticulata, Phebalium diosmeum, Gompholobium grandiflorum, Helichrysum diosmifolium and *Olearia ramulosa.*

The herb flora is much more abundant in forest communities than in the scrub. *Xanthosia pilosa, Halorrhagis teucrioides* and *Dianella coerulea* are frequently occurring herbs. Scattered tufts of grasses occur, but do not form a characteristic feature of the undergrowth. They are more frequent in slightly disturbed areas, such as along roadsides. A number of geophytes with a brief sub-aerial development are frequent though inconspicuous. Many of these are orchids, including species of *Acianthus, Caladenia, Cryptostylis, Diuris, Microtus, Prasophyllum, Pterostylis* and *Thelymitra.*

A few root parasites occur, such as the Native Cherry Tree, *Exocarpus cupressiformis,* and the shrubs, *Olax stricta, Choretrum lateriflorum* and *Leptomeria acida.* Of the epiphytic types, *Loranthus* species are frequent parasites on species of *Eucalyptus* and *Casuarina,* whilst the twining parasitic *Cassytha* spp. show no preference for hosts, but are usually limited to the shrub strata.

A number of creepers also occur, e.g., *Smilax glycyphylla, Clematis aristata, C. glycinoides, Kennedya rubicunda, Hardenbergia monophylla,* and *Billardiera scandens.*

The following species are typical of moist areas, where seepage water collects: *Gahnia psittacorum, G. tetragonocarpa, Schoenus melanostachys, Restio tetraphyllus, Gleichenia flabellata* and *Bauera rubioides.*

Gully Flora.—On south and south-east slopes, and lower slopes of deep gullies, where insolation is less intense than on northerly and westerly slopes, there occurs a much less sclerophyllous shrub flora than that typical of much of the tall scrub-forest. This flora may be conveniently referred to as "gully flora".

These shrubs, which indicate more equable conditions of growth, must still be classed as part of the sclerophyll formation, but their leaves are often larger and of softer texture than those of the typical sclerophylls.

Ceratopetalum gummiferum and *Dodonaea triquetra* are the first indicators of the gully flora. *Gompholobium latifolium, Pultenaea flexilis* and *Grevillea linearis* also frequently occur intermingled with the characteristic sclerophyllous undershrubs.

The following are the shrubs and trees characteristic of the community referred to as "gully flora": *Grevillea linearis* R.Br., *Hakea saligna* R.Br., *Lomatia longifolia* R.Br., *Rubus rosaefolius* Sm., *Acacia linearis* Sims., *A. longifolia* Willd., *Hovea longifolia* R.Br., *Pultenaea flexilis* Sm., *Phebalium dentatum* Sm., *P. squamulosum* Vent., *Dodonaea triquetra* Wendl., *Pomaderris elliptica* Labill., *P. lanigera* Sims., *Elaeocarpus reticulatus* Sm., *Leptospermum flavescens* Sm., *Myrtus tenuifolia* Sm., *Astrotricha floccosa* DC., *A. ledifolia* DC., *Acrotriche divaricata* R.Br., *Notelaea longifolia* Vent., *Logania floribunda* R.Br., *Olearia stellulata* DC.

The number of these shrubs occurring in any area depends on the habitat. On slopes, they are usually intermingled with the sclerophyllous shrubs typical of the tall scrub-forest. In the vicinity of creeks (Pl. 3, fig. 22) they are present to the exclusion of hardier types.

Mesophytic Element.—Along many creeks (Pl. 3, fig. 24) in sheltered gullies there is an admixture of mesophytes with the sclerophyllous "gully flora". This is best interpreted as an invasion by some hardier sub-tropical rain-forest species and indicates soil moisture, shelter and humidity approaching those required by sub-tropical rain-forest. This mesophytic element does not belong floristically to the sclerophyll forests, but must be mentioned here on account of its intimate ecological association.

The following includes the species interpreted as sub-tropical rain-forest elements: *Drimys insipida* Druce, *Eupomatia laurina* R.Br., *Doryphora sassafras* Endl., *Endiandra Sieberi* Nees, *Abrophyllum ornans* Hook., *Quintinia Sieberi* A.DC., *Schizomeria ovata* D. Don, *Synoum glandulosum* A. Juss., *Breynia oblongifolia* J. Muell., *Phyllanthus Ferdinandi* J. Muell., *P. Gasstroemii* J. Muell., *Backhousia myrtifolia* Hook. & Harv., *Tieghemopanax sambucifolius* R. Viguier.

It is sometimes very difficult to decide whether some species belong to sub-tropical rain-forests or are better classified as gully-flora types. Such species of doubtful floristic affinities are *Ceratopetalum apetalum* D. Don, *Callicoma serratifolia* Andr., *Tristania laurina* R.Br., *T. neriifolia* R.Br., *Pittosporum revolutum* Ait., *P. undulatum* Andr.

High Forest.

High forest is the most highly integrated of the sclerophyllous forests developed on the Hawkesbury Sandstone. The average height of the trees is about 80 feet, although they vary from 60 to 100 feet. The undershrubs attain a height of 3–5 feet. High forest requires conditions of good soil moisture, as found only in gullies in the area under review. It is therefore confined to the relatively few wide open gullies, which present a favourable topographical habitat. The lack of space and limited soil depth and extent in the more typical, narrow, precipitous, sandstone gullies allows the development of only a few scattered trees of the species typical of high forest. Moreover, the exclusive development of *Eucalyptus* in such narrow gullies is very often prevented by the degree of shade and humidity, which favours the development of mesophytic shrubs and trees. In more open gullies, the increased insolation and decreased humidity prevent competition from mesophytes.

E. pilularis, *E. piperita* and *Angophora lanceolata* are the most important trees in this community. The most frequent undershrubs are: *Grevillea linearis*, *Persoonia linearis*, *P. pinifolia*, *P. salicina*, *Acacia discolor*, *A. linifolia*, *Dillwynia ericifolia*, *Gompholobium grandiflorum*, *G. latifolium*, *Platylobium formosum*, *Pultenaea daphnoides*, *Zieria Smithii* and *Dodonaea triquetra*.

The following "gully flora" species often occur and may form dense thickets: *Acrotriche divaricata*, *Elaeocarpus reticulatus*, *Lomatia longifolia*, *Hakea saligna*, *Logania floribunda*, *Pomaderris elliptica*, *Hovea longifolia*, *Breynia oblongifolia*, *Acacia linearis* and *Notelaea longifolia*. *Astrotricha floccosa* often forms layer societies while *Pultenaea flexilis*, *Leptospermum flavescens*, *Grevillea linearis*, and *Callicoma serratifolia* form group societies, usually in the vicinity of creeks. *Ceratopetalum apetalum*, *Pittosporum* spp. and *Eugenia Smithii* also frequently fringe the creeks. *Tristania laurina* and *T. neriifolia* occur in rocky creeks.

The following climbers are usually found near creeks: *Sarcopetalum Harveyanum*, *Tecoma australis*, *Geitonoplesium cymosum*, *Eustrephus Brownii*, and *Hibbertia dentata*.

A few herbs, such as *Plectranthus parviflorus*, *Brunella vulgaris*, *Viola hederacea* and *Hydrocotyle hirta*, are restricted by soil moisture conditions to the neighbourhood of creeks.

Ferns are often locally abundant and flourish particularly well in the vicinity of water-courses. The most frequent species are *Culcita dubia*, *Gleichenia flabellata*, *G. circinata*, *Blechnum cartilagineum*, *B. capense* and *Adiantum hispidulum*. A fern stratum, in which shrubs are absent or scattered, sometimes occurs on shady gully slopes (Pl. iii, fig. 23).

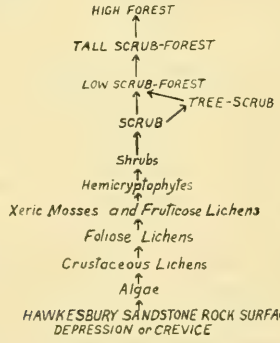
(b) Moist Lithosere.

In moist habitats the succession differs from that described above as the xeric lithosere, at least in the early seral phases. In creeks and gullies, in addition to moisture abundance, temperature and humidity are generally much more favourable than on the plateau, so that the rocks are colonized by a less xeric flora.

Various Types.

(i) Crevice communities, which have already been mentioned in connection with the xeric lithosere, are characterized by different species when they occur in moist, shady habitats. Of these species, *Gleichenia circinata*, *Doodia aspera*, *D. caudata*, *Culcita dubia* and *Dracophyllum secundum* are amongst the most typical.

(ii) Very often rocks on the slopes in sunny situations receive considerable seepage. Here, lichens are usually absent, but algae and mosses are the first colonizers and are succeeded by low shrubs and herbs such as: *Epacris microphylla*, *Actinotus minor*, *Hypolaena lateriflora*, *Mitrasacme polymorpha*, *Dracophyllum secundum*, *Bauera rubioides* and *Epacris longiflora*. *Gleichenia dicarpa*, *Bauera rubioides* and *Hypolaena lateriflora* often form pure societies. Species of *Drosera* and geophytic orchids may also be present. A peaty-humus soil is built up under these conditions. *Callistemon linearis*, *Leptospermum parviflorum* and *L. arachnoideum* frequently occur as taller shrubs near such wet rock-ledges. Probably these seepage banks will persist throughout the forest as long as the drainage remains unaltered.



Schematic Representation of the Phases of the Xeric Lithosere.

(iii) On continually moist and shady rock-ledges, etc., in the vicinity of creeks or water channels, a sere is initiated by liverworts and mosses, of which the following are important: *Fossombronia* spp., *Pallavacinnia* spp. *Symphyogyna* spp., *Aneura* spp., *Polytrichum* spp., *Podomitrium* spp., *Dawsonia* spp.

The small amount of peaty soil developed in the vicinity of these dripping rock-ledges supports a distinct type of flora. In the moss mats, sundews such as *Drosera spathulata* and *D. binata*, rapidly become established. In the sheltered areas ferns are prominent and include *Gleichenia circinata*, *G. flabellata*, *Asplenium flabellifolium*, *Blechnum capense*, and more rarely *Adiantum hispidulum* and *Doodia aspera*. *Todea barbara* is frequent in rocky creeks. Any of the herbs typical of seepage banks may also occur, especially *Dracophyllum* and *Hypolaena*.

Lycopodium laterale and *Epacris crassifolia* have also been recorded. Under moist rock-ledges in extreme shelter, *Schizaea rupestris*, associated with liverworts, forms little colonies. In the vicinity of creeks, larger shrubs such as *Callicoma serratifolia* ultimately become established. This type of community reaches a high stage of development in the gorges of the Blue Mts., where many additional species are of common occurrence.

(iv) On loose rock-boulders in the vicinity of creeks in moist sheltered gullies, there is a rich lithophytic flora whose presence is due mainly to the humidity and low light intensity. Lichens do not form a conspicuous feature here. The rocks are frequently covered by mosses and the filmy fern *Hymenophyllum tunbridgense*. The ferns *Cyclophorus serpens*, *Polypodium Billardieri* and *Asplenium flabellifolium* also occur in the dense moss mats, and the orchids *Bulbophyllum Shepherdi*, *B. exiguum*, *Dendrobium linguiforme* and *Liparis reflexa* are frequently present. Many of the orchids found here also occur in more exposed situations, especially *D. linguiforme*.

Swamps.

Deficient drainage often characterizes a series of comparatively level areas on the plateau. Water accumulates, giving a high water-table, and the sere culminates in a swamp, usually of very limited extent. In the Bulli district (Davis, 1936), however, the swamps are of considerable size.

The analogy between colonization here and the early stages of the xeric lithosere is partly maintained by the similar trend of life forms. There is, however, a greater preponderance of rush or sedge-like hemicryptophytes in the wettest areas.

On wet or moist rocks, lichens are not important. Mosses form extensive mats in which herbs such as *Drosera* spp., *Utricularia* spp. and geophytic orchids rapidly make their appearance. This initial sequence is especially shown in rock crevices (Pl. iv, fig. 31). *Lepyrodia scariosa*, *Restio complanatus* and *Baeckea crenulata* typically appear at this stage. Some rocks subject to moist conditions show "vegetation islands" similar to those described in the xeric lithosere, the only differences being the much thicker and denser moss carpet and the occurrence of moisture tolerant species.

A record of the specific sequence in this moist lithosere would be without special value since the trend of succession and the ultimate composition of any particular swamp vary with the degree of soil saturation.

It is convenient to recognize at least two types of swamps, (*a*) sedge swamp (Pl. iii, fig. 26; iv, fig. 27) characterized by hemicryptophytes, chamaephytes and geophytes, and (*b*) shrub swamp (Pl. iv, fig. 30), containing a number of similar species, but with the addition of numerous low, woody shrubs which are scattered throughout and impart a definite physiognomic character to the community. This is distinct from the moist scrub of the xeric lithosere.

(*a*) Sedge swamps occur in the wettest areas where the soil is waterlogged for most of the year and free water is often present on the soil surface. The soil in these swamps is very rich in plant remains which form an acid type of humus.

The dominant species belong chiefly to the Cyperaceae and Restionaceae and include the following: *Lepidosperma flexuosum*, *Schoenus brevifolius*, *S. Moorei*, *Restio complanatus*, *R. australis*, *Xyris complanata*, *X. gracilis*, *X. operculata*, *Leptocarpus tenax*, *Hypolaena lateriflora*, *Lepyrodia scariosa* and *Restio tetraphyllus*. Small, erect, slender shrubs of *Epacris obtusifolia* and *Sprengelia incarnata* also occur. Smaller herbs and ground flora include: *Drosera binata*, *D. pygmaea*, *D. spathulata*, *Utricularia lateriflora*, *U. dichotoma*, *U. cyanea*,

Goodenia bellidifolia, G. stelligera and *Lycopodium laterale.* In the wettest parts of the swamps, in soaks and drainage channels, *Banksia latifolia, Gahnia psittacorum, Gleichenia dicarpa, Chorizandra sphaerocephala* and *Gymnoschoenus adustus* occur (Pl. iii, fig. 26; iv, figs. 29, 30).

(*b*) Shrub swamps are fairly frequent on the uplands in areas which are not wet enough for the development of sedge swamps. The most frequently occurring shrubs are *Banksia latifolia* var. *minor, Xanthorrhoea hastilis, Baeckea crenulata, B. densifolia, Dillwynia floribunda, Kunzea capitata, Epacris obtusifolia, Sprengelia incarnata, Bauera rubioides, Angophora cordifolia, Callistemon lanceolatus, C. linearis, Viminaria denudata, Sphaerolobium vimineum, Olax stricta, Persoonia salicina, Hakea pugioniformis, Melaleuca squarrosa,* and *Leptospermum lanigerum.* Prominent amongst the herbs are: *Actinotus minor, Schoenus deustus, Lepyrodia scariosa, Burchardia umbellata, Selaginella uliginosa, Costularia paludosa, Lepidosperma laterale, Hypolaena lateriflora, Sowerbaea juncea, Dracophyllum secundum, Lobelia anceps, Halorrhagis micrantha, Eriochilus autumnalis, Drosera pygmaea, Blandfordia nobilis, Symphyonema paludosum,* and *Stackhousia viminea.* Occurring with these shrubs and herbs are several sedge-like species such as *Schoenus brevifolius, Lepidosperma flexuosum, Restio complanatus* and *Leptocarpus tenax.*

As in all other communities, there is a series of gradations between the two types of swamps. Swamps of an intermediate character in which *Xanthorrhoea hastilis, Banksia latifolia* var. *minor* and a few other shrubs occur scattered amongst the sedge-like species, are frequently found (Pl. iv, fig. 28).

Around the margins of sedge swamps where the ground is drier, the "peat" thinner and the amount of mineral matter greater, shrubs often become frequent and may increase in numbers until finally a shrub swamp is formed. Again, in any areas of drier ground within the sedge swamp, there is an aggregation of moisture-tolerant shrubs. Conversely, small patches of sedge-swamp occur in wet hollows in shrub swamps.

Shrub swamps frequently grade imperceptibly into wet scrub communities, or the ecotone may be through a low forest community such as described above (p. 12) (Pl. ii, fig. 19), in which *E. micrantha* and *E. gummifera* are dominants.

Shrub swamps are intermediate between the moist scrubs of the xeric lithosere and the sedge swamps of the moist lithosere. These must, however, be classed as swamps rather than as a type of wet scrub, because of the high percentage of organic matter present in the soils. This fact is illustrated in Table 2 (cf. Table 3), in which the percentage loss on ignition may be taken as a rough estimate of the humus content. The soil analyses were estimated from typical shrub and sedge swamp communities.

TABLE 2.

Community Type.	Soil Depth. (Inches.)	Percentage Water-Retaining Capacity.	Percentage Loss on Ignition.
Shrub swamp	4	40	8·5
	24	26	—
Sedge swamp	4	60	12·8
	24	42	—

A tabular list of species in the appendix indicates the range of the chief species in the various types of scrub and swamp communities.

2. Secondary Succession.

The subseres so far have not been studied in any detail, but a few relevant observations have been made and are recorded here.

In the area studied, secondary succession is initiated on areas which have been denuded by the agency of man. The widespread occurrence of fires is one of the most important means of destruction of the flora.

Succession in Disturbed Areas.—Colonization on secondary bare areas, such as disused gravel roads, is frequent. Here, there is a certain amount of loose sand and larger rock particles, and conditions for growth are less extreme than on bare rock faces. Consequently the lichen and moss flora characteristic of the xeric lithosere are absent; colonization by the hardiest hemicryptophytes and shrubs is most frequent. Species of the Restionaceae, Cyperaceae and other families, such as *Hypolaena fastigiata, Schoenus imberbis, Lepidosperma laterale, Lepyrodia scariosa* and *Lomandra glauca* are typical pioneers. The variety of shrub species present is partly dependent on the nature of the surrounding community. Types such as *Casuarina rigida, Bossiaea scolopendria, Angophora cordifolia* and *Leucopogon microphylla* often occur.

Grasses often become locally dominant in disturbed areas, as on roadsides, and subsequently may enter the neighbouring forest. Weeds and introduced plants frequently become established in slightly disturbed areas and so spread into undisturbed localities, especially along watercourses, e.g., *Rubus fruticosus* (blackberry), *Lonicera* spp. (honeysuckle), *Solanum* spp. and *Ageratum conyzoides.*

Pyric Succession.—The controlling influence of fires on the development of *Eucalyptus* forests has been discussed by Petrie (1925), and Jarrett and Petrie (1929). The forest fire is regarded as a great simplifying factor which has led to the elimination of types not possessing powers of rapid regeneration. Fires not only modify the structure of forests, but lead to the increased density and purity of the components. In the area under review, the comparative paucity of species in some localities is outstanding. This may be attributed to repeated fires, in which the complete elimination of many species has taken place.

The amount of destruction varies according to the intensity of the fire; the tree strata are not always destroyed, but the undershrubs usually are. Most species of *Eucalyptus* are capable of regenerating by epicormic shoots (Pl. iv, fig. 32). As discussed above (p. 8), survival occurs by seeds or by the unharmed subterranean organs. In the re-establishment of a similar type of community which occurs fairly rapidly, the aggregation of seeds and the renascence of plants already within the community are more important than migration from adjacent unburned areas. The dense stands of subordinate *Eucalyptus* strata which are frequently observed suggest post-pyric development.

As Petrie (1925) has pointed out, *Pteridium aquilinum* regenerates and spreads rapidly after fires, and if the habitat is especially favourable, the natural undershrubs may have to withstand severe competition during re-establishment. If a succession of fires happens to occur in any one area, the undershrubs may fail to gain the ascendancy and so the *Pteridium* society remains dominant. *Imperata cylindrica* var. *Koenigii* forms a stratum society in a similar manner. These two species frequently intermingle, forming one stratum (Pl. iv, fig. 33).

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Conclusions.

The sclerophyll vegetation discussed in this paper is a part of the Mixed *Eucalyptus* Forest Association previously referred to (Pidgeon, 1937).

The general physiognomy of the sandstone *Eucalyptus* Forests, and their low degree of integration, have been commented on by Petrie (1925). The occurrence of practically the same species in the scrub flora as amongst the undershrubs of low scrub-forests, and the ability of the lower strata to persist unaltered wherever the growth of trees is inhibited, is an indication of this lack of inter-dependence. However, the gradual change in the constituents of the shrub flora from low scrub-forests to more advanced communities suggests a certain degree of dependence on the tree stratum. This change is chiefly due to the reduction in the amount of light reaching the shrub layer. The higher soil-moisture content is also an important factor, especially in the establishment of undershrub species recorded as "gully flora".

The vegetation has been discussed as consisting of well-defined structural communities, but all of these grade into one another, thus forming ecotones. The type communities as described are very constant and widely distributed, not only in the area studied, but in other Hawkesbury Sandstone localities. In the Hornsby and Blue Mountains Plateaux there is a much greater percentage of scrub and low scrub-forest vegetation than in the southern sandstone plateau (Nepean Ramp), where tall scrub-forest covers most of the uplands. The physiographic and edaphic conditions which control these differences have already been discussed.

So far, the various communities have been considered as static units of vegetation; an interpretation from the point of view of succession will now be given.

Succession. (1) *Swamps.*—It is doubtful what the ultimate fate of the swamps will be, even if drainage conditions remain constant. The surface of the swamps may gradually be raised by accumulation of plant remains, and eventually become occupied by a shrubby vegetation. Very often the presence of an underlying fairly impermeable layer would prevent this. In the sedge swamps at least, the peaty soil, by its high water-retaining capacity, tends to keep the swamp at the same stage of development. The depth of the peat in some areas suggests that the swamps have remained relatively unchanged over long periods, and there is no reason to believe that they would not continue so until drained. This moist lithosere is, therefore, interpreted as a deflected succession (Godwin, 1929).

(2) *Scrub and Forest.*—Topographical restriction of the communities is obvious. On the uplands, scrub, tree-scrub, and low scrub-forests predominate, interspersed with swampy patches. On slopes and in gullies, various types of tall scrub-forests are most frequent, with low scrub-forests on portions of the upper slopes, and sometimes high forest on gully floors and lower slopes. A mesophytic element also occurs on the latter habitats in very moist sheltered areas. Passing from an exposed ridge to a sheltered gully, the whole sequence of the above-mentioned communities is usually encountered. This spatial sequence is determined by increasingly favourable conditions of growth such as shelter from wind, higher humus-content, and consequently higher water-retaining capacity, and higher soil-moisture content. This is very clearly brought out in Table 3. The figures give typical values for the communities under consideration.

It can therefore be concluded that the distribution of communities is closely correlated with soil type and aspect. The sequence of plant communities is therefore not so much a succession in the sense of Clements (1916) as a physiographic succession.

TABLE 3.

Community Type.	Soil Horizon.	Percentage Water-Retaining Capacity.	Percentage Loss on Ignition.
Scrub	A1	27	3
	A2*	25	
Low scrub-forest	A1	30	4
	A2	27	
Tall scrub-forest (sclerophyllous undershrubs)	A1	38	7
	A2	30	
High forest (with gully flora)	A1	68	17
	A2	37	

* A2 horizon is at a depth of eight inches. Scrub soils frequently do not show a marked A2 horizon; at this depth it is usually a B horizon.

Only in the early stages of the sere, from the pioneer communities to the scrub, does autogenic succession occur (Tansley, 1935), indicated by zonation. In these pioneer communities, biotic reactions within the community are initially responsible for succession. Deficiencies in water and nutrients become less extreme by the accumulation of humus and the development of soil, whilst the shade afforded by the developing vegetation reduces the temperature extremes.

Since the progression from scrub to forest vegetation is controlled in the first place by topography, this part of the succession is allogenic.

The development of communities higher in the sere than scrub is dependent on shelter from severe wind and more favourable soil conditions. Frequently an extremely shallow and rocky soil may be the limiting factor in the progression to a scrub-forest. In areas of similar soil depth, aspect is often the deciding factor in the development of scrub, tree-scrub, and low scrub-forests.

Well-developed tall scrub-forests require a much higher soil-moisture content than the previous types. This is attained in the first place by topographical shelter with consequent low evaporation rate and high soil-moisture, and secondly by high water-retaining capacity owing to a high humus-content.

The development of high forest is even more restricted owing to the lack of space and shallow nature of the soil in many of the otherwise favourable gully habitats. Scrub-forests are the most widely distributed vegetation type over the sandstone area under review.

The physiographic influence on the succession is emphasized by the distribution of *Eucalyptus* species. A frequently occurring series of species from ridge to gully is here given. *E. haemastoma* and *E. gummifera* are typical of the uplands and ridges, although the latter descends into the valleys; *E. punctata* and *E. micrantha* frequently occur on the upper slopes of the gullies; *Angophora lanceolata* and *E. piperita* are more frequent on the middle and lower slopes; *E. pilularis* is practically confined to the lower slopes and gully floors.

The highest type of development of this physiographic succession on the Hawkesbury Sandstone is high forest. This is perhaps the only community of the Mixed *Eucalyptus* Forest Association which approaches the typical development of

the climax *Eucalyptus* Forest Formation. The sub-tropical rain-forest element belongs to another formation, but partially replaces the more slowly growing sclerophyll vegetation where water is not a limiting factor. On the sandstone, the former occurs only in patches in deep sheltered gullies in extreme conditions of shelter, soil moisture and humidity.

The status to be accorded to the plant communities of the area is largely a matter of personal interpretation. Davis (1936) has interpreted the plateau forests as the climax and the gully forests as post-climax vegetation on sandstone soils. He similarly distinguishes between climaxes and post-climaxes developed on soils derived from different geological formations. According to this interpretation, the same association is a climax on one soil and a post-climax on another soil. He also uses the term 'post-climax' in reference to rain-forest vegetation, i.e., in the sense of Clements, and it seems unnecessary to employ it in any other sense.

Following Clements' classification (1936), scrub and low scrub-forest may be regarded as serclimaxes, tall scrub-forest as subclimax, and high forest as climax. However, it appears to the writer that each serclimax or subclimax is most satisfactorily considered as a physiographic climax (Tansley, 1935) for, so long as the present physiographic conditions are maintained, these communities will persist.

Summary.

Plant succession of the sclerophyll vegetation on the Hawkesbury Sandstone is described. Primary Succession is discussed as a xeric and moist lithosere. The development of the xeric lithosere, from the pioneer communities to the climax, is described.

The sequence of the initial phases is: Algae, Crustaceous Lichens, Foliose Lichens, Xeric Mosses and Fruticose Lichens, Hemicryptophytes and Shrubs. Special types of succession of these pioneer stages are mentioned.

The structure, physiognomy and composition of the mature plant communities are described. These are scrub, tree-scrub, low scrub-forest, tall scrub-forest and high forest. Their distribution is discussed from the point of view of topographical habitats.

A fairly detailed account is given of the floristic composition of the scrub. The forest communities are discussed as structural entities. The undershrub floras of various forest types are compared, and an indication of the specific communities of *Eucalyptus* spp. is given. The admixture of mesophytic plants in the sclerophyll vegetation is recorded. Various types of moist lithoseres are described, and the swamp sere is discussed as an example of deflected succession. Comment is made on the widespread effect of fire on the development of the vegetation.

An interpretation is given of the development of the vegetation as a process of physiographic succession; the succession is regarded as being allogenic rather than autogenic.

The writer wishes to thank all those who assisted in this work, especially Professor T. G. B. Osborn and Assistant-Professor J. McLuckie for their interest and guidance throughout. Thanks are also due to Dr. Lilian Fraser for her helpful criticism, to Miss M. Wilson for her assistance in photography, and to Mr. O. D. Evans for identification of many specimens.

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EXPLANATION OF PLATES I-IV.

Plate i.

1.—Colonies of crustaceous lichens. 2.—Foliose lichens. 3.—Foliose lichen colonies, with a central colony of xeric mosses. 4.—Vertical face of a sandstone boulder covered by lichens and mosses. 5.—Vertical rock-face with colonies of *Dendrobium striolatum* growing in moss mats. 6.—Sandstone surface covered by lichens with mosses and *Cyclophorus serpens* on vertical face. *Xanthorrhoea hastilis* top left. 7.—Rock ledge covered by dense moss mat with hemicryptophytes and shrubs. 8.—Moss mat with tufts of *Lepyrodia scariosa* and litter of dry leaves and twigs. 9.—Initial seral phases in lateral sequence. 10.—Crevice communities of *Xanthorrhoea hastilis*. 11.—Crevice community consisting of various shrub species.

Plate ii.

12.—A "vegetation island" consisting mainly of *Lepidosperma laterale* in dense moss mat. Island of *Casuarina rigida* in background. 13.—Early seral stages in lateral sequence. Moss mat with tufted hemicryptophytes, *Dianella coerulea* at left. 14.—Scrub on plateau surface exposed to westerly wind. Stunted tree-scrub of *E. haemastoma* in foreground. 15.—Moist scrub with *Banksia ericifolia* and *Hakea pugioniformis* in tall stratum (8 ft. approx.). Low shrub and herb strata exposed by disturbance. 16.—Dry scrub on coastal headland. 17.—As in 16. *Westringia rosmariniformis* (right foreground) and *Casuarina rigida* forming crevice communities. 18.—Low scrub-forest on plateau surface; shrub swamp in foreground. 19.—Forest of *E. micrantha*, about 30-40 feet; bordering swamp.

Plate iii.

20.—A typical gully, Hornsby Plateau. 21.—Undulating plateau surface with shrub swamp in foreground and forests on sheltered slopes. 22.—Tall scrub-forest with gully flora near creek in foreground. 23.—High forest (about 80 ft. high) of *E. agglomerata* (left) and *Angophora lanceolata* (right), with fern stratum and *Xanthorrhoea arborea* in foreground. 24.—Mesophytic element along creek bank. 25.—"Vegetation island" of *Baeckea densifolia* in moist area. 26.—Sedge swamp with shrubs of *Banksia latifolia*.

Plate iv.

27.—Sedge swamp bordered by forest. *Xanthorrhoea hastilis* on right. 28.—Mixed community of sedges with *Xanthorrhoea hastilis* and *Banksia latifolia* var. *minor*. Figs. 26, 27, 28 represent stages of increasing dryness. 29.—Sedge swamp with society of *Gahnia psittacorum* (centre). 30.—Seepage area with *Gleichenia dicarpa* and *Chorizandra* spp. in foreground; shrub swamp in middle ground, succeeded by scrub-forest. 31.—Colonization of rock ledge in sedge swamp. Crevice communities of mosses, *Drosera* spp. and *Restio complanatus*. 32.—Forest of *Eucalyptus* spp. regenerating after fire by epicormic shoots. 33.—Stratum society of *Pteridium aquilinum* and *Imperata cylindrica* var. *Koenigii*.

APPENDIX.

TABLE 1.

Table 1 contains a list of the most typical species occurring in the dry and moist scrub, and in the shrub and sedge swamps. No attempt has been made to give a complete list of the flora of the various communities. In the distribution of the species, as indicated in the four columns, " × " represents typical occurrence and " – " indicates the presence of a species which is unimportant in that particular community. The range of species from the left to the right column may be interpreted on the basis of increasing moisture tolerance.

	Dry Scrub.	Moist Scrub.	Shrub Swamp.	Sedge Swamp.
Pteridophyta				
Lycopodium laterale R.Br.				×
Selaginella uliginosa Spring			×	–
Gleichenia dicarpa R.Br.				×
Cyperaceae				
Caustis flexuosa R.Br.				
C. pentandra R.Br.	×			
C. recurvata Spreng.	×			
Chorizandra sphaerocephala R.Br.				×
Costularia paludosa C. B. Clarke	–	×	×	
Gahnia psittacorum Labill.				×
Gymnoschoenus adustus Nees				×
Lepidosperma flexuosum R.Br.	×	×	×	×
L. laterale R.Br.	×	×	×	
L. filiforme Labill.	×			
Schoenus brevifolius R.Br.		×	×	
S. deustus F.v.M.	×		×	×
S. Moorei Benth.			–	
Restionaceae				
Leptocarpus tenax R.Br.	–	×	×	×
Lepyrodia scariosa R.Br.	×	×	×	×
Hypolaena fastigiata R.Br.	×	×	×	×
H. lateriflora Benth.			×	×
Restio australis R.Br.				×
R. complanatus R.Br.		×	×	
R. dimorphus R.Br.	×			
R. fastigiatus R.Br.				
R. tetraphyllus Labill.				×
Xyridaceae				
Xyris complanata R.Br.				×
X. gracilis R.Br.				×
X. operculata Labill.				
Liliaceae				
Blandfordia nobilis Sm.			×	×
Burchardia umbellata R.Br.	×	×	×	
Dianella coerulea Sims	×	×		
Sowerbaea juncea Sm.			×	–
Xanthorrhoea hastilis R.Br.	×	×	×	–
Lomandra glauca Ewart	×			
L. obliqua Macbride	×			
L. longifolia Labill.	×			
Haemodoraceae				
Haemodorum teretifolium R.Br.	×	–	–	
Orchidaceae				
Eriochilus autumnalis R.Br.			×	–
Casuarinaceae				
Casuarina rigida Miq.	×			
Proteaceae				
Banksia ericifolia Linn.	×	×		
B. latifolia R.Br. var. *minor* Maiden and Camfield	–	×	×	×
Grevillea Caleyi R.Br.	×			
G. punicea R.Br.	×	×	–	
Hakea acicularis R.Br.	×	×	–	
H. dactyloides Cav.	×			
H. pugioniformis Cav.	×	×	×	
Isopogon anemonifolius R.Br.	×	–	–	
I. anethifolius R.Br.	×	–	–	
Lambertia formosa Sm.	×	–	–	
Persoonia lanceolata Andr.	×	×	–	
P. salicina Pers.	×	×	×	
Petrophila pulchella R.Br.	×	–		
Symphyonema paludosum R.Br.			×	
Santalaceae				
Leptomeria acida R.Br.	–	–	×	
Olacaceae				
Olax stricta R.Br.	–	–	–	
Droseraceae				
Drosera binata Labill.				×
D. peltata Sm.			–	
D. pygmaea DC.			×	×

TABLE 1.—*Continued.*

	Dry Scrub.	Moist Scrub.	Shrub Swamp.	Sedge Swamp.
D. spathulata Labill.			–	×
Saxifragaceae				
Bauera rubioides Andr.	–	×	×	
Leguminosae				
Acacia discolor Willd.	×			
A. myrtifolia Willd.	×			
Aotus villosa Sm.		×	×	
Bossiaea ensata Sieb.	×	–		
B. heterophylla Vent.	×	–		
B. scolopendria Sm.	×	–		
Dillwynia ericifolia Sm.	×	×		
D. floribunda Sm.	–	×	×	
Phyllota phylicoides Benth.	×			
Pultenaea elliptica Sm.	×			
Sphaerolobium vimineum Sm.		×	×	
Viminaria denudata Sm.		×	×	
Rutaceae				
Boronia ledifolia J. Gay	×	×		
Philotheca australis Rudge	×			
Euphorbiaceae				
Micrantheum ericoides Desf.	×	×	×	
Ricinocarpus pinifolius Desf.	×			
Stackhousiaceae				
Stackhousia viminea Sm.			×	
Thymelaeaceae				
Pimelea linifolia Sm.	×	×	–	
Myrtaceae				
Angophora cordifolia Cav.	×	×	×	
Baeckea crenulata R.Br.	–	×	×	
B. densifolia Sm.			×	
Callistemon lanceolatus DC.		–	×	
C. linearis DC.		–	×	
Calycothrix tetragona Labill.	×			
Darwinia fascicularis Rudge	×			
Kunzea capitata Reichb.	×	×	×	
Leptospermum arachnoideum Sm.	×	×	–	
L. lanigerum Sm.		×	×	
L. scoparium Forst.	×	×	×	
L. stellatum Cav.	×	×	×	
Melaleuca squarrosa Don.			×	
Micromyrtus microphylla Benth.	×			
Umbelliferae				
Actinotus minor DC.	×	×	×	
Trachymene linearis Spreng.	–	–	×	
Epacridaceae				
Brachyloma daphnoides Benth.	×			
Epacris longiflora Cav.	×			
E. microphylla R.Br.	×	×	–	
E. obtusifolia Sm.		×	×	×
E. pulchella Cav.	×	–		
Leucopogon microphylla Spreng.	×	×		
Monotoca scoparia R.Br.	×			
Sprengelia incarnata Sm.		×	×	×
Styphelia triflora Andr.	×			
Woollsia pungens F.v.M.	×			
Loganiaceae				
Mitrasacme polymorpha R.Br.	×	×	×	
Lentibulariaceae				
Utricularia cyanea R.Br.				×
U. dichotoma Labill.				×
U. lateriflora R.Br.				×
Goodeniaceae				
Goodenia bellidifolia Sm.	–	×	×	×
G. stelligera R.Br.			×	×
Dampiera stricta R.Br.	×	×	×	
Candolleaceae				
Candollea linearis F.v.M.	×	×		

TABLE 2.

Table 2 comprises a list of the most frequent shrub species occurring in dry scrub, and in the shrub strata o plateau forests (chiefly low scrub-forest), and gully forests (tall scrub-forest and high forest). Species typical of seepage areas throughout the forests are omitted. The distribution of species is represented by the same symbols as in Table 1. The range of the species is controlled by light and soil moisture factors. In these columns, conditions of shade and soil moisture become increasingly favourable from left to right.

	Dry Scrub.	Plateau Forest.	Gully Forest.
Casuarinaceae			
Casuarina rigida Miq.	×		
Proteaceae			
Banksia ericifolia Linn.	×	×	
B. spinulosa Sm.	–	×	×
Grevillea buxifolia R.Br.	×	×	–
G. linearis R.Br.			×
G. punicea R.Br.	×	×	–
G. sericea R.Br.	×	×	–
Hakea acicularis R.Br.	×	×	
H. dactyloides Cav.	×	×	×
H. saligna R.Br.			×

TABLE 2.—*Continued.*

	Dry Scrub.	Plateau Forest.	Gully Forest.		Dry Scrub.	Plateau Forest.	Gully Forest.
Isopogon anemonifolius R.Br.	×	×		Polygalaceae			
Lambertia formosa Sm.	×	×		*Comesperma ericinum* DC.	–	×	
Lomatia longifolia R.Br.			×	Euphorbiaceae			
L. silaifolia R.Br.	–	×	–	*Amperea spartioides* Brongn.	×		
Persoonia lanceolata Andr.	×	×	×	*Breynia oblongifolia* J.Muell.			×
P. linearis Andr.			×	*Phyllanthus Gasstroemii* J.Muell.			×
P. pinifolia R.Br.		–	×	*Ricinocarpus pinifolius* Desf.	×	×	
P. salicina Pers.	×	×	×	Sapindaceae			
Petrophila pulchella R.Br.	×	×	–	*Dodonaea triquetra* Wendl.			×
Santalaceae				Rhamnaceae			
Leptomeria acida R.Br.	–	×	×	*Pomaderris elliptica* Labill.			×
Saxifragaceae				*P. lanigera* Sims			×
Bauera rubioides Andr.	–	–	×	*Elaeocarpus reticulatus* Sm.			×
Cunoniaceae				Dilleniaceae			
Ceratopetalum gummiferum Sm.		–	×	*Hibbertia dentata* R.Br.			×
Leguminosae				*H. stricta* R.Br.	×	×	
Acacia discolor Willd.	×	×	×	Thymelaeaceae			
A. linearis Sims			×	*Pimelea linifolia* R.Br.	×	×	–
A. linifolia Willd.	–	×	×	Myrtaceae			
A. longifolia Willd.			×	*Angophora cordifolia* Cav.	×		
A. myrtifolia Willd.	×	×	×	*Darwinia fascicularis* Rudge	×	×	
A. suaveolens Willd.	×	×		*Kunzea capitata* Reichb.	×	×	
Aotus villosa Sm.	–	×	–	*Leptospermum scoparium* Forst.	×	×	
Bossiaea microphylla Sm.	–	×	–	*L. flavescens* Sm.			×
B. scolopendria Sm.	×	–		Araliaceae			
Dillwynia ericifolia Sm.	×	×	×	*Astrotricha floccosa* DC.			×
D. floribunda Sm.	–	×	–	*A. ledifolia* DC.			×
Gompholobium grandiflorum Sm.			×	Umbelliferae			
G. latifolium Sm.			×	*Trachymene linearis* Spreng.	–	×	×
Hovea linearis R.Br.	×	×	×	Epacridaceae			
H. longifolia R.Br.			×	*Epacris longiflora* Cav.	×	×	–
Indigofera australis Willd.			×	*E. microphylla* R.Br.	×	×	–
Oxylobium trilobatum Benth.		–	×	*E. pulchella* Cav.	×	×	–
Phyllota phylicoides Benth.	×	×		*Leucopogon amplexicaulis* Rudge		–	×
Platylobium formosum Sm.	–	–	×	*L. ericoides* Sm.	×	×	
Pultenaea daphnoides Wendl.	–	–	×	*L. lanceolatus* R.Br.		–	×
P. elliptica Sm.	×	×		*Monotoca scoparia* R.Br.	×	–	
P. flexilis Sm.			×	*Styphelia triflora* Andr.	×	×	
P. stipularis Sm.	–	×	×	*S. longifolia* R.Br.	–	×	×
Rutaceae				*Woollsia pungens* F.v.M.	×	×	×
Boronia pinnata Sm.	–	×	×	Loganiaceae			
B. ledifolia J. Gay	–	×	×	*Logania floribunda* R.Br.			×
Eriostemon Crowei F.v.M.	–	–	×	Labiatae			
E. lanceolatus Gaertn.	–	–	×	*Prostanthera empetrifolia* Sieb.			×
Phebalium dentatum Sm.			×	*P. linearis* R.Br.			×
P. diosmeum A. Juss.			×	Compositae			
P. squamulosum Vent.			×	*Olearia ramulosa* Benth.		×	×
Philotheca australis Rudge	×	×		*O. stellulata* DC.			×
Zieria pilosa Rudge	×	×	–	*Cassinia denticulata* R.Br.			×
Z. Smithii Andr.		×		*Helichrysum diosmifolium* Don			×
Tremandraceae							
Tetratheca ericifolia Sm.	×	×					

Ecology of Central Coastal Area, N.S.W.

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Ecology of Central Coastal Area, N.S.W.

REVISION OF AUSTRALIAN LEPIDOPTERA. OECOPHORIDAE. VII.

By A. Jefferis Turner, M.D., F.R.E.S.

[Read 30th March, 1938.]

67. Gen. Eulechria Meyr. (continued).

700. Eulechria autophyla Low., *Tr.R.S.S.Aust.*, 1899, 105 (Broken Hill).

701. Eulechria ductaria Meyr., *Exot. Micro.*, i, 159 (Tasmanian Mts.).

702. Eulechria chorodoxa Meyr., ibid., ii, 372 (Toowoomba).

703. Eulechria sordidella Wlk., xxix, 755 (= *psammochroa* Low., *Tr.R.S.S.Aust.*, 1894, 97; *petrinodes* Low., ibid., 1901, 89; *relevata* Meyr., *Exot. Micro.*, ii, 373) (Duaringa to Scone, Broken Hill).

704. Eulechria rhadinosticha, n. sp. (ῥαδινοστιχος, with slender lines.)

♂. 27–30 mm. Head grey. Palpi with second joint reaching base of antennae, terminal joint three-fourths; grey. Antennae grey; ciliations in male 1½. Thorax fuscous. Abdomen grey; tuft grey-whitish. Legs grey. Forewings elongate, narrow, somewhat dilated, costa slightly arched, apex pointed, termen very oblique; pale grey with slight fuscous irroration towards margins; a slender fuscous line on lower margin of cell from one-fourth to its angle, and a suffused spot on its upper angle; a faint interrupted fuscous terminal line; cilia whitish, on tornus pale grey. Hindwings with 5 from middle; grey-whitish; cilia whitish.

A peculiar species, something like *Philobota hiracistis*, but with much narrower forewings.

Queensland: Adavale in May; two specimens.

705. Eulechria paraleuca Low., *Tr.R.S.S.Aust.*, 1907, 114; Meyr., *Exot. Micro.*, i, 162 (Milmerran, Broken Hill. Hoyleton, S.A.)

706. Eulechria laxeuta Meyr., *Exot. Micro.*, i, 130 (Townsville, Bowen, Charters Towers).

707. Eulechria centrotona Meyr., ibid., i, 300 (Hoyleton).

708. Eulechria orecta, n. sp. (ὀρεκτος, stretched out.)

♂, ♀. 28–31 mm., 35 mm. Head and thorax fuscous sprinkled with whitish. Palpi with terminal joint one-half; fuscous. Antennae fuscous; ciliations in male 1. Legs fuscous; posterior pair pale grey. Forewings elongate, costa gently arched, apex rounded, termen obliquely rounded; fuscous finely sprinkled with whitish, appearing grey; stigmata obsolete; cilia grey. Hindwings and cilia pale grey.

Queensland: Adavale in March; five specimens.

709. Eulechria physica Meyr., *Exot. Micro.*, i, 371 (Cape Naturaliste, W.A.).

710. Eulechria centroleuca, n. sp. (κεντρολευκος, whitish in the middle.)

♀. 25–26 mm. Head whitish-brown. Palpi with second joint reaching base of antennae, terminal joint three-fifths; whitish-grey. Antennae and thorax fuscous. Abdomen fuscous; tuft ochreous-whitish. Legs fuscous with whitish rings; femora grey; posterior tibiae whitish-ochreous. Forewings rather narrow,

suboblong, costa gently arched, apex rounded, termen obliquely rounded; fuscous-grey; median area broadly suffused with grey-whitish; this is broadest at base and narrows to second discal, expanding again towards termen; a smaller grey-whitish suffusion above posterior half of dorsum; stigmata dark fuscous, first discal at one-third, plical beneath it, second discal well before two-thirds; a sub-marginal series of dark fuscous dots from two-thirds costa to tornus; cilia fuscous barred with whitish. Hindwings and cilia fuscous.

Agreeing with *Eulechria* in all other respects, the two specimens have no pecten. The species is referred here provisionally.

Queensland: Maryland, near Stanthorpe, in November and December; two specimens received from Mr. W. B. Barnard, who has the type.

711. EULECHRIA SCIAPHILA Turn., *P.R.S.Tas.*, 1926, 144 (Tasmanian Mts.).

712. EULECHRIA PHILOTHERMA Meyr., P.L.S.N.S.W., 1882, 534 (= *hemichrysa* Low., *Tr.R.S.S.Aust.*, 1916, 540) (Mackay to Sydney, Dalby, Chinchilla, Gisborne).

713. EULECHRIA BASIXANTHA, n. sp. (*βασιξανθος*, yellow at the base.)

♀. 24 mm. Head fuscous; face pale yellow. Palpi with second joint reaching base of antennae, terminal joint four-fifths; whitish-ochreous. Antennae, thorax, and abdomen fuscous. Forewings suboblong, costa scarcely arched, apex rounded, termen obliquely rounded; fuscous; a broad yellow basal fascia extending to one-fourth; in it three short basal fuscous streaks, one oblique from base of costa, one on fold, and the third on base of dorsum; a yellow triangle on three-fourths costa; a blackish spot on fold follows basal part; and another precedes apex of costal triangle; cilia fuscous. Hindwings and cilia fuscous.

The type is somewhat worn, but its colour scheme is unique in this genus.

Queensland: Macpherson Range (3,500 feet) in February; one specimen.

714. EULECHRIA MESOPHRAGMA Meyr., P.L.S.N.S.W., 1887, 950 (Mittagong, Cooma, Gisborne, Lorne, Tasmania).

715. EULECHRIA MEDIOLINEA, n. sp. (*mediolineus*, streaked through the middle.)

♀. 17 mm. Head and thorax grey. Palpi with second joint reaching base of antennae, terminal joint three-fifths; whitish, a subapical ring on second joint, a sub-basal ring on terminal joint, and some irroration, fuscous. Antennae grey. Abdomen pale grey. Legs ochreous-whitish; anterior pair fuscous. Forewings narrow, costa slightly arched, apex pointed, termen very oblique; grey-whitish with sparse fuscous irroration; a fine longitudinal fuscous streak below middle from one-fifth to three-fifths; a similar but shorter streak midway between this and costa; an incomplete dentate subterminal line; cilia whitish with fuscous points. Hindwings and cilia pale grey.

Queensland: Toowoomba in September; one specimen received from Mr. W. B. Barnard.

716. EULECHRIA PICIMACULA, n. sp. (*picimaculus*, with pitch-black markings.)

♀. 19 mm. Head and thorax fuscous-grey. Palpi with second joint slightly exceeding base of antennae, terminal joint two-thirds; grey. Antennae and abdomen grey. Legs fuscous; posterior pair whitish-ochreous. Forewings narrow, costa nearly straight to three-fourths, apex pointed, termen very oblique; grey; markings blackish; a short subcostal longitudinal streak near base; a broad oblique bar from one-third costa to fold; second discal at two-thirds, rather large, some suffusion before and beyond it; cilia grey. Hindwings with 3 and 4 stalked; 5 from below middle; pale-grey; cilia pale grey.

Queensland: Brisbane in April; one specimen.

717. EULECHRIA DYSIDES, n. sp. (δυσειδης, uncomely.)

♂, ♀. 15–20 mm. Head ochreous-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; ochreous-whitish, external surface except apex of second joint suffused with fuscous. Antennae fuscous; ciliations in male two-thirds. Thorax ochreous-whitish, anterior edge fuscous. Abdomen grey; tuft ochreous-whitish. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish. Forewings suboval, costa moderately arched, apex pointed, termen very oblique; ochreous-whitish with patchy fuscous irroration and markings; sometimes an ill-defined suffused costal streak; a fine streak from base along fold; a sub-basal dorsal spot; stigmata small or minute, first discal at one-third, plical slightly beyond, second discal well before two-thirds, double or semilunar, a dot above and beyond first discal; a large apical suffusion; a terminal series of dots; cilia ochreous-whitish. Hindwings and cilia pale grey.

Queensland: Nambour in October and November; Stradbroke I. in August and October; Tweed Heads in August; six specimens.

718. EULECHRIA OCHLOPHILA, n. sp. (ὀχλοφιλος, rejoicing in crowds.)

♂. 15–18 mm. Head whitish-brown. Palpi with terminal joint reaching base of antennae, terminal joint three-fifths; fuscous, inner surface, apex of second joint, and usually most of terminal joint, ochreous-whitish. Antennae ochreous-whitish annulated with fuscous; ciliations in male 1½. Thorax whitish-brown with some fuscous scales. Abdomen whitish-grey; bases of segments ferruginous-fuscous. Legs fuscous with ochreous-whitish rings; posterior pair whitish-ochreous. Forewings slightly dilated, costa gently arched, apex pointed, termen oblique; whitish-brown partly suffused with brown, sometimes sprinkled with fuscous; markings fuscous; a small basal patch extending further on costa than dorsum; a spot on one-fourth costa and a larger triangular spot on midcosta; stigmata dark fuscous, first discal at one-third, plical before it, second discal before two-thirds, a dot just above and beyond first discal, another beneath second discal; a line from four-fifths costa obliquely inwards, angled above middle, and gently curved to tornus; an incomplete subterminal line, a terminal series of dots; cilia whitish-brown. Hindwings with 5 from middle; whitish-grey, cilia whitish.

North Queensland: Malanda and Millaa Millaa, very abundant in September; but I found only the one sex. Queensland: a wasted specimen from the Bunya Mts. in January is probably the same species.

719. EULECHRIA BATHROGRAMMA Turn., P.L.S.N.S.W., 1916, 359 (Atherton, Nambour and Bunya Mts., to Ebor).

720. EULECHRIA EMBOLOGRAMMA Turn., ibid., 1916, p. 258 (= *embolistis* Turn., *Tr.R.S.S.Aust.*, 1917, 65) (Tweed Hds., Mt. Tambourine, Macpherson Range).

721. EULECHRIA LEUCODELTA, n. sp. (λευκοδελτος, with white triangle.)

♀. 14–20 mm. Head pale ochreous or white. Palpi with second joint reaching base of antennae, terminal joint three-fifths; pale ochreous or whitish, base of second and apex of terminal joint fuscous. Antennae fuscous. Thorax pale ochreous or white; tegulae fuscous. Abdomen dark fuscous. Legs fuscous; with whitish rings; posterior pair paler. Forewings suboval, costa moderately arched, apex rounded, termen obliquely rounded; fuscous; a large white triangle with truncated apex on costa shortly before middle, base from one-fourth dorsum to tornus; a whitish spot on costa at three-fourths; cilia fuscous. Hindwings elongate-ovate; grey; cilia grey.

Queensland: Mt. Tambourine in November; National Park (3,500 feet) in December; three specimens.

722. EULECHRIA STRAMENTARIA Turn., P.L.S.N.S.W., 1916, 258 (Ebor).

723. EULECHRIA EUZANCLA, n. sp. (*εὐξαγκλος*, with well formed sickles.)

♂. 20 mm. Head and face white sprinkled with grey. Palpi with second joint reaching base of antennae, terminal joint 1; whitish, external surface of second joint except apex, and anterior edge of terminal joint, fuscous. Antennae whitish-grey; ciliations in male 1. Abdomen grey, apices of segments grey-whitish; tuft ochreous-whitish. Legs fuscous; posterior pair ochreous-whitish. Forewings rather narrow, costa gently arched, apex pointed, termen very oblique; white finely sprinkled with grey, denser in terminal area; stigmata fuscous, minutely linear, first discal at one-third, plical slightly beyond it, second discal before two-thirds, a dot above and midway between discals, another above and beyond plical, a sixth below second discal; cilia whitish. Hindwings with 5 from middle; grey-whitish; cilia grey-whitish.

North Queensland: Cape York in June; one specimen received from Mr. W. B. Barnard.

724. EULECHRIA PLESIOSTICTA, n. sp. (*πλησιοστικτος*, with clustered dots.)

♂. 16 mm. Head ochreous-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, apex of second joint and part of inner surface whitish. Antennae grey, towards base fuscous; ciliations in male 1. Thorax whitish. Abdomen grey; apices of segments and tuft grey-whitish. Legs fuscous; posterior pair whitish. Forewings suboblong, costa moderately arched, apex round-pointed, termen very oblique; whitish; patchy fuscous suffusion on costa before and beyond middle, on mid-dorsum, and in terminal area; stigmata dark fuscous, small but distinct, first discal at one-third, plical well beyond it, second discal before two-thirds, a dot above and between discals, another beneath second discal; cilia pale grey. Hindwings and cilia whitish-grey.

North Queensland: Babinda in August; one specimen.

725. EULECHRIA CRYPTEA, n. sp. (*κρυπτεος*, concealed.)

♂, ♀. 18–24 mm. Head whitish. Palpi with second joint reaching base of antennae, terminal joint four-fifths; grey. Antennae grey; ciliations in male 1. Thorax grey; patagia usually whitish. Abdomen pale grey with some brown suffusion on dorsum. Legs grey; posterior pair whitish. Forewings oval, costa moderately arched, apex round-pointed, termen very oblique; grey; stigmata fuscous, first discal at one-third, plical beyond it, second discal at two-thirds, a dot above and between discals, sometimes a dot beneath second discal and another at tornus; cilia grey. Hindwings and cilia grey.

North Queensland: Eungella in October. Queensland: Yeppoon in October; Brisbane in August. Seven specimens.

726. EULECHRIA PSATHYROPA Turn., *P.R.S.Tas.*, 1926, 146 (Cradle Mt.).

727. EULECHRIA OCHROMOCHLA, n. sp. (*ωχρομοχλος*, with a pale bar.)

♀. 14 mm. Head and thorax fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, apex and inner surface of second joint and apex of terminal joint ochreous-whitish. Antennae fuscous. Abdomen grey. Legs fuscous, with whitish-ochreous rings; posterior pair mostly ochreous-whitish. Forewings narrow, suboval, costa gently arched, apex round-pointed, termen very obliquely rounded; ochreous-whitish densely sprinkled with fuscous; a broad ochreous streak on dorsum; stigmata fuscous, very obscure, first discal not traceable, plical more distinct, second discal before two-thirds; less fuscous

irroration in terminal area; cilia fuscous, extreme apices ochreous-whitish. Hindwings and cilia grey.

Queensland: National Park (3,000 feet) in November; one specimen received from Mr. W. B. Barnard.

728. EULECHRIA EREMOTROPHA, n. sp. (*ἐρημοτροφος*, bred in the desert.)

♂. 20 mm. Head grey. Palpi with second joint just reaching base of antennae (terminal joint broken off); grey. Antennae grey; ciliations in male 1. Thorax fuscous. Abdomen pale ochreous-grey; tuft whitish-ochreous. Legs grey; posterior pair whitish-ochreous. Forewings narrowly oval, costa moderately arched, apex pointed, termen very oblique; whitish grey with uniform fuscous irroration; first discal at one-fourth, plical elongate, ill-defined, beneath and beyond this. second discal at three-fifths, transversely elongate, curved; cilia grey. Hindwings and cilia pale grey.

Queensland: Charleville; one specimen.

729. EULECHRIA DOCHMOTYPA, n. sp. (*δοχμοτυπος*, obliquely marked.)

♀. 20 mm. Head and thorax fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; grey. Antennae fuscous. Abdomen reddish-brown; apices of segments grey. Legs fuscous with whitish rings. Forewings suboval, costa strongly arched near base, thence nearly straight, apex pointed, termen very oblique; grey with dark fuscous markings; first discal at one-third, minute, plical beyond it, larger, second discal at two-thirds, connected by a broken line with tornus; a series of dots close to margin around apical fifth of costa and termen; cilia grey. Hindwings and cilia grey.

Queensland: Toowoomba in November; one specimen received from Mr. W. B. Barnard.

730. EULECHRIA MELANOGYPSA, n. sp. (*μελανογυψος*, black and white, chalky.)

♀. 20 mm. Head white. Palpi with second joint reaching base of antennae, terminal joint four-fifths; fuscous, apex of second and base of terminal joint whitish. Antennae fuscous. Thorax dark fuscous; tegulae and posterior margin white. Abdomen ferruginous; sides grey; apices of segments grey-whitish. Legs fuscous; posterior pair ochreous-whitish. Forewings elongate, costa rather strongly arched, apex pointed, termen very oblique; white; markings dark fuscous; some suffusion along costa to two-thirds; first discal at one-third, plical beyond it, second discal before two-thirds; a dot above and between discals; plical connected with a small dorsal blotch; second discal connected with tornus; an inwardly oblique streak from five-sixths costa, emitting a strongly curved line to tornus; a terminal series of dots; cilia whitish. Hindwings with 5 from middle; grey; cilia grey.

New South Wales: Brunswick Heads in January; one specimen received from Mr. W. B. Barnard.

731. EULECHRIA ACROCAPNA, n. sp. (*ἀκροκαπνος*, with dark apex.)

♂. 19 mm. Head and thorax whitish-brown. Palpi with second joint reaching base of antennae, terminal joint three-fourths; brown-whitish sprinkled with fuscous. Antennae pale grey; ciliations in male 1. Abdomen grey; tuft grey-whitish. Legs whitish-ochreous. Forewings sub-oval, costa moderately arched, apex pointed, termen very obliquely rounded; brown-whitish with fuscous irroration and markings; an undefined basal fuscous area; ill-defined costal spots at one-third and two-thirds; first discal at one-fourth, minute, plical beneath it, minute, second discal at three-fifths, larger, connected with second costal spot;

an apical blotch, from which runs an interrupted terminal line to tornus; cilia brown-whitish sprinkled with fuscous. Hindwings and cilia pale grey.

New South Wales: Ebor in December; one specimen.

732. Eulechria stereospila, n. sp. (στερεοσπιλος, with spots in line.)

♂, ♀. 20–25 mm. Head brownish. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; brown-whitish sprinkled with fuscous. Antennae grey; ciliations in male 2½–3. Thorax brown-whitish; anteriorly broadly fuscous. Abdomen ochreous-brown; apices of segments and tuft pale grey. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish. Forewings narrow, strongly dilated, costa straight except near base and apex, apex rounded, termen obliquely rounded, brown-whitish sparsely sprinkled with fuscous; markings dark fuscous; a small suffused basal fascia; stigmata moderate, first discal at one-fourth, plical slightly beyond it, second discal just beyond middle, a dot midway between and in a line with discals; a subapical blotch connected with costa, variable in size, extending as a line to a marginal pretornal spot; terminal area often pale, with a terminal line and fine connecting lines between this and blotch; cilia brown-whitish, bases sprinkled with fuscous. Hindwings and cilia pale grey.

This species is distinguished by the median dot being in a line with, and not above, discals.

New South Wales: Mt. Kosciusko (5,000 feet) in January. Victoria: Gisborne in September and October. Ten specimens.

733. Eulechria comorrhoa, n. sp. (κομορρόος, with flowing hair.)

♂, ♀. 18–20 mm. Head and thorax fuscous-brown. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; ochreous-whitish with more or less fuscous irroration. Antennae ochreous-whitish with fine fuscous annulations; ciliations in male 6. Abdomen pale ochreous-grey. Legs fuscous with whitish-ochreous rings; posterior pair whitish-ochreous. Forewings rather narrow, dilated posteriorly, costa gently arched, apex rounded, termen very obliquely rounded; pale brownish; markings and some irroration fuscous; a narrow, suffused basal fascia; first discal at one-fifth, plical beyond it, second discal slightly beyond middle, a dot, sometimes elongate, midway between discals; sometimes connected by a fine streak with one or both of them; a suffused outwardly curved line from four-fifths costa to tornus, from which run fine streaks to termen enclosing a series of brownish terminal dots, cilia pale brownish with a few fuscous points. Hindwings grey; cilia whitish-grey.

Smaller than *E. stereospila*, forewings not dilated, stigmata smaller, often confluent, no subapical blotch, antennal ciliations much longer.

Queensland: National Park (3,000 feet) in November. New South Wales: Sydney in September. Victoria: Ringwood, near Melbourne, in October. Four specimens.

734. Eulechria zalodes, n. sp. (ζαλωδης, storm-troubled.)

♂. 15 mm. Head white; side-tufts on crown fuscous. Palpi with second joint not quite reaching base of antennae, terminal joint four-fifths; white, second joint with basal and subapical, terminal joint with broad median rings. Antennae grey; ciliations in male 2. Thorax fuscous; apices of tegulae white. Abdomen grey; tuft whitish. Legs whitish; anterior pair fuscous. Forewings narrow, costa slightly arched, apex rounded, termen very obliquely rounded; white sprinkled with dark fuscous and largely suffused with grey towards dorsum and base; a white spot on base, another on costa near base, and a larger irregular spot on

midcosta; a white fascia from three-fourths costa almost reaching termen; dark fuscous markings consist of an irregular sub-basal fascia, an incomplete fascia at one-third, a better developed fascia from two-thirds costa to tornus, and a small terminal blotch; cilia white sprinkled with dark fuscous. Hindwings and cilia pale grey.

Victoria: Mt. Buffalo in January; one specimen.

735. EULECHRIA CEPHALANTHES Meyr., P.L.S.N.S.W., 1887, 949 (Albany, W.A.).

736. EULECHRIA GLAPHYROTA Meyr., ibid., 1887, 959 (Albany, Perth, W.A.).

737. EULECHRIA NOTERA, n. sp. (*νοτερος*, moist.)

♂. 18–20 mm. Head pale ochreous. Palpi with second joint not reaching base of antennae, terminal joint one-half; fuscous, inner surface whitish. Antennae grey; ciliations in male 1. Thorax and abdomen grey. Legs grey; posterior pair whitish. Forewings narrow, slightly dilated, costa moderately arched, apex pointed, termen very oblique; glossy pale grey; stigmata obsolete, or minute discals present at one-third and two-thirds; cilia pale grey. Hindwings and cilia grey, slightly darker than forewings.

Tasmania: Mt. Wellington (2,500 feet) in January; six specimens.

738. EULECHRIA PEDIAULA, n. sp. (*πεδιαυλος*, living on the plains.)

♂. 18 mm. Head and thorax whitish. Palpi with second joint not reaching base of antennae, terminal joint two-thirds; whitish, outer surface of second joint except apex fuscous. Antennae whitish-grey; ciliations in male one-half. Abdomen pale grey. Legs grey; posterior pair ochreous-whitish. Forewings narrow, oval, costa moderately arched, apex rounded, termen obliquely rounded; white finely sprinkled with grey; a small grey spot beneath end of cell; cilia white sprinkled with grey. Hindwings and cilia grey-whitish.

Queensland: Charleville in September; two specimens.

739. EULECHRIA METALEUCA, n. sp. (*μεταλευκος*, whitish posteriorly.)

♂. 20 mm. Head and thorax grey. Palpi with second joint reaching base of antennae, terminal joint three-fourths; grey. Antennae grey; ciliations in male 8. Abdomen grey; tuft whitish. Legs whitish (anterior pair missing). Forewings very narrow, costa slightly arched, apex rounded, termen very oblique; glossy whitish-grey; a suffused white fascia from three-fourths costa to tornus; some scattered fuscous scales on terminal area beyond this; cilia white. Hindwings whitish; cilia white.

The extremely long antennal ciliations should be noted.

Tasmania: Mt. Wellington (2,500 feet) in January; one specimen.

740. EULECHRIA FENISECA Meyr., *Exot. Micro.*, i, 300 (Sydney).

741. EULECHRIA OCHROPHARA, n. sp. (*ὠχροφαρος*, in pale clothing.)

♂. 18 mm. Head and thorax ochreous-grey-whitish. Palpi with second joint reaching base of antennae, somewhat thickened and rough anteriorly in middle, terminal joint two-thirds; ochreous-grey-whitish. Antennae whitish-grey; ciliations in male 6. Abdomen grey. Legs pale ochreous-grey (posterior pair missing). Forewings suboblong, costa gently arched, apex rounded, termen obliquely rounded; pale greyish-ochreous; markings and some scattered scales fuscous; a suffused costal triangle before middle; a fine line from one-third dorsum towards but not reaching apex of this triangle; discals approximated, plical obsolete, first discal at two-fifths, second at three-fifths, a dot beneath second; a suffused line from two-thirds costa obliquely outwards, sharply curved in middle and continued to tornus; a terminal series of dots; cilia pale greyish-ochreous with some fuscous points. Hindwings whitish with pale grey suffusion towards apex; cilia whitish.

Not near any other species, though it agrees with *E. metaleuca* in the long antennal ciliations.

Tasmania: Strahan in February; one specimen.

742. Eulechria atmopis Meyr., P.L.S.N.S.W., 1888, 1605 (Magnetic Is., Toowoomba, Dalby, Warwick).

743. Eulechria gypsota Low., *Tr.R.S.S.Aust.*, 1893, 177 (= *decolor* Turn., P.L.S.N.S.W., 1916, 352) (Gisborne, Castlemaine, Mt. Lofty).

744.† Eulechria pentaspila Low., ibid., 1900, 41 (Broken Hill).

745. Eulechria phoryntis Meyr., *Tr.R.S.S.Aust.*, 1902, 150 (Gisborne).

746. Eulechria plicilinea, n. sp. (*plicilineus*, with a line on fold.)

♀. 24 mm. Head grey-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; grey. Antennae grey. Thorax fuscous. Abdomen grey. Legs grey; posterior pair whitish. Forewings elongate, costa gently arched, apex pointed, termen very oblique; grey with some patchy whitish suffusion in mid-disc and towards dorsum; markings dark fuscous; first discal at one-third, plical represented by a short streak below and beyond it, second discal by a fine transverse curved line at two-thirds; a dot above and between discals; a fine line from four-fifths costa to tornus, sinuous above; some minute terminal dots; cilia pale grey. Hindwings and cilia grey-whitish.

Queensland: Maryborough in May; one specimen.

747. Eulechria celata Meyr., *Exot. Micro.*, i, 160 (Gisborne).

748. Eulechria tanyscia Meyr., P.L.S.N.S.W., 1883, 322 (South Australia).

749.† Eulechria cyphocentra Meyr., *Exot., Micro.*, ii, 511 (Dalby).

750. Eulechria fulvitincta, n. sp. (*fulvitinctus*, brownish-tinged.)

♂. 18–20 mm. Head and thorax grey. Palpi with second joint reaching base of antennae, terminal joint two-thirds; fuscous, apex of second joint whitish. Antennae grey; ciliations in male 1¼. Legs fuscous; posterior tibiae whitish. Forewings not dilated, costa moderately arched, apex rounded, termen obliquely rounded; pale grey, sparsely sprinkled with fuscous, with some brownish suffusion in disc; markings dark fuscous; a short streak from base on fold; first discal at one-third, plical well beyond it, second discal before two-thirds, followed by some brownish suffusion, a dot between and above discals; a line of dots from three-fourths costa, angled before termen, and continued to tornus; cilia pale grey. Hindwings whitish-grey; cilia whitish.

New South Wales: Sydney in August; two specimens received from Mr. G. M. Goldfinch, who has the type.

751. Eulechria acedesta, n. sp. (ἀκηδεστος, uncared for.)

♀. 26 mm. Head and thorax fuscous. Palpi with second joint exceeding base of antennae, somewhat dilated towards apex, terminal joint three-fourths; fuscous, apex and posterior surface of second joint white. Antennae grey. Abdomen grey. Legs fuscous; posterior pair whitish sprinkled with grey. Forewings elongate, posteriorly dilated, costa gently arched, apex round-pointed, termen very obliquely rounded; whitish, densely and uniformly irrorated with grey; markings very obscure, fuscous; first discal at one-third, plical slightly beyond, second discal before two-thirds, a dot above and between discals; a postmedian line faintly indicated towards costa; cilia grey, apices whitish. Hindwings and cilia pale grey.

New South Wales: Scone in January; one specimen received from Mr. H. T. Nicholas.

752. Eulechria adoxella Meyr., P.L.S.N.S.W., 1882, 540 (= *aquaria* Meyr., *Exot. Micro.*, i, 132) (Toowoomba to Melbourne. Tasmania. Albany, Denmark, Waroona, W.A.).

753.† EULECHRIA PERPETUA Meyr., ibid., i, 160 (Cairns).

754. EULECHRIA AMAURA Meyr., P.L.S.N.S.W., 1882, 538 (Brisbane to Lorne. Albany, Waroona, W.A.).

755. EULECHRIA AMAUROPIS, n. sp. (*ἀμαυρωπις*, dark.)

♂. 23–27 mm.; ♀. 30 mm. Head and thorax fuscous sparsely sprinkled with whitish. Palpi slender, second joint just reaching base of antennae, terminal joint less than one-half; fuscous sprinkled with whitish. Antennae grey; ciliations in male 1. Abdomen brownish-grey. Legs fuscous sprinkled with whitish. Forewings elongate, narrow, not dilated, costa gently arched, apex rounded, termen obliquely rounded; fuscous with more or less whitish irroration, especially in centre; sometimes with darker streaks on veins; stigmata dark fuscous, first discal at one-fourth, plical beneath or slightly beyond, a median dot above middle, second discal beyond middle, a dot beneath it; a very obscure subterminal line of dots indented beneath costa; cilia grey, bases fuscous mixed with whitish. Hindwings and cilia grey.

Near *E. amaura*, but the palpi are much shorter.

Queensland: Talwood in April; eleven specimens received from Mr. W. B. Barnard, who has the type.

756. EULECHRIA NIPHOBOLA Low., *Tr.R.S.S.Aust.*, 1920, 61 (Broken Hill).

757. EULECHRIA MEGALOPHANES, n. sp. (*μεγαλοφανης*, large.)

♂. 32–35 mm. Head fuscous or grey. Palpi with second joint reaching base of antennae, terminal joint three-fourths; grey sprinkled with whitish. Antennae grey; ciliations in male 1. Thorax fuscous. Abdomen grey. Legs grey; posterior pair whitish-grey. Forewings elongate, slightly dilated, costa moderately arched, apex rounded, termen obliquely rounded; grey with fuscous markings; first discal before one-third, plical beneath it, second discal before two-thirds, a dot between and above discals, sometimes another beneath and before second; suffused costal spots at three-fifths and four-fifths; from the latter a slender curved line to tornus; a suffused spot between second discal and tornus; cilia grey. Hindwings grey-whitish; cilia pale grey.

New South Wales: Mt. Kosciusko in December; two specimens received from Mr. G. M. Goldfinch, who has the type.

758.† EULECHRIA MOBILIS Meyr., *Exot. Micro.*, i, 300 (Mt. Kosciusko).

759. EULECHRIA GONOSTROPHA Low., *Tr.R.S.S.Aust.*, 1896, 166 (Broken Hill).

760. EULECHRIA PEDETIS Meyr., P.L.S.N.S.W., 1883, 488 (Mittagong. Victoria. South Australia).

761. EULECHRIA OCHROCNECA, n. sp. (*ὠχροκνεκος*, pale yellowish.)

♂. 28–32 mm. Head and thorax grey. Palpi with second joint reaching base of antennae, terminal joint three-fourths; grey. Antennae grey; ciliations in male three-fourths. Abdomen pale grey. Legs fuscous; posterior pair pale grey. Forewings elongate-oval, costa strongly arched, apex pointed, termen very obliquely rounded; grey sprinkled with grey-whitish; markings fuscous; first discal before one-third, plical beyond it, second discal before two-thirds, a dot above and between discals; a line from two-thirds costa, at first transverse, then angled strongly outwards, finally curved and ending on tornus; an interrupted terminal line; cilia grey. Hindwings with 5 from much below middle; whitish-ochreous with more or less grey suffusion towards apex and termen; cilia pale grey, on dorsum whitish-ochreous.

Near *E. erebodes*, but with paler yellowish hindwings, and with plical dot beyond first discal.

Victoria: Gisborne in January (G. Lyell); Beaconsfield in November (W. E. Drake); three specimens. Type in National Museum, Melbourne.

762. EULECHRIA EREBODES Meyr., P.L.S.N.S.W., 1883, 487 (Toowoomba to Melbourne).

763. EULECHRIA PYCNODA Low., *Tr.R.S.S.Aust.*, 1907, 116 (Darwin to Charleville and Milmerran).

764. EULECHRIA ATRISIGNIS Low., P.L.S.N.S.W., 1900, 45 (= *erebomorpha* Low., ibid., 1900, 46) (Broken Hill. Birchip).

765. EULECHRIA CREPERA Meyr., ibid., 1883, 484 (= *xiphopepla* Low., *Tr.R.S.S. Aust.*, 1920, 59) (Stanthorpe to Melbourne. Tasmania. Adelaide).

766. EULECHRIA METAXUTHA, n. sp. (*μεταξουθος*, tawny posteriorly.)

♂. 28 mm. Head and thorax fuscous. Palpi with second joint exceeding base of antennae, terminal joint two-thirds; fuscous. Antennae grey; ciliations in male 1. Abdomen pale grey; apices of segments and tuft ochreous-yellow. Legs fuscous; posterior pair ochreous-yellow. Forewings narrow, slightly dilated, costa slightly arched, apex rounded, termen very obliquely rounded; fuscous; a broad white subcostal streak from costal edge near base to three-fourths; stigmata dark fuscous, first discal on lower edge of streak before one-third, second before two-thirds, a dot in streak above and between them; a few white scales before apex; cilia fuscous. Hindwings grey suffused with ochreous; cilia ochreous-yellow.

Near *E. argotoxa*, but readily distinguished by the hindwings.

Federal Capital Territory: "Blundell's" (2,500 feet) in March; one specimen.

767. EULECHRIA ARGOTOXA Meyr., P.L.S.N.S.W., 1888, 1608 (Mittagong. Victoria. Mt. Lofty).

768. EULECHRIA POLYBALIA, n. sp. (*πολυβαλιος*, much spotted.)

♂. 20–23 mm. Head pale grey. Palpi with second joint reaching base of antennae, terminal joint three-fourths; grey-whitish, second joint towards base and extreme apex of terminal fuscous. Antennae grey; ciliations in male 1½. Thorax pale grey with fine fuscous irroration. Abdomen pale grey. Legs fuscous with whitish rings; posterior pair whitish. Forewings elongate, dilated posteriorly, costa slightly arched or nearly straight, apex rounded, termen obliquely rounded; pale grey with general fine fuscous irroration; markings fuscous; an elongate median dot near base; first discal at one-third, plical well before it, elongate, second discal much before two-thirds; small suffused spots on costa at one-third and before two-thirds; a suffused spot on dorsum near base, and another before tornus, sometimes suffusedly connected with second discal; a thick oblique streak inwards from costa before apex, giving off a line towards tornus, but not going far; a series of dots or short streaks on apical sixth of costa and termen; cilia whitish with some basal fuscous bars. Hindwings and cilia grey-whitish.

Western Australia: Perth (G. H. Hardy and W. H. Matthews); three specimens.

769. EULECHRIA MACROSTOLA, n. sp. (*μακροστολος*, long-robed.)

♂. 22–32 mm. Head grey-whitish; face grey. Palpi with second joint reaching base of antennae, loosely rough-haired anteriorly, terminal joint one-half; grey, base and apex of second joint whitish. Antennae grey; ciliations in male one-half. Abdomen ochreous-grey-whitish, towards apex grey; tuft grey-whitish. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings elongate, narrow, posteriorly dilated, costa slightly arched, more so towards base and apex, apex rounded, termen very obliquely rounded; 2 and 3 connate or stalked; white with blackish irroration and markings, appearing grey; a subcostal

line from base of costa to one-third, edged above and sometimes interrupted by whitish; a similar line from one-fifth along lower margin of cell, bent at a right angle and continued over its posterior margin; a median subcostal dot; fine radiating lines from posterior margin of cell; a broadly suffused inwardly oblique streak from five-sixths costa, sharply bent outwards beneath costa, and continued parallel to termen to dorsum before tornus; from this line proceed ten radiating streaks to termen; cilia white, with interrupted basal and subapical blackish lines. Hindwings and cilia grey-whitish.

Queensland: Milmerran in July and August; three specimens received from Mr. J. Macqueen.

770. Eulechria ebenospora, n. sp. (*ἐβενοσπορος*, spotted with black.)

♀. 27 mm. Head whitish. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; whitish, terminal joint and base of second joint fuscous. Antennae grey-whitish. Thorax whitish with some grey suffusion. Abdomen whitish-grey; bases of middle segments ferruginous. Forewings elongate, not dilated, costa gently arched, apex round-pointed, termen very oblique; whitish; markings and a few scattered scales fuscous; a stout but very short subcostal streak from base of costa; first discal at one-third, plical before and connected with it, second discal before two-thirds, rather large, a spot midway and directly between discals; a suffused curved line from three-fifths costa, through second discal to tornus; a subapical spot, from which runs a slender line to tornus; cilia whitish, around apex sprinkled with brownish. Hindwings and cilia whitish.

New South Wales: Adaminaby (3,500 feet) in October; one specimen.

771. Eulechria pissographa, n. sp. (*πισσογραπτος*, with pitch-black markings.)

♂. 24 mm. Head whitish-ochreous. Palpi with second joint slightly exceeding base of antennae, terminal joint four-fifths; whitish-ochreous, external surface of second, except apex, blackish. Antennae whitish-grey with blackish annulations towards base; ciliations in male 3. Thorax dark fuscous with a large posterior ochreous-whitish spot. Abdomen whitish-ochreous; grey-brown towards base. Legs ochreous-whitish; anterior pair fuscous. Forewings moderate, slightly dilated, costa straight, but arched towards base and apex, apex rounded, termen obliquely rounded; ochreous-whitish; markings and some irroration black; a broad streak on basal fifth of costa; stigmata large, first discal before one-third, plical beyond and connected with it by some fuscous irroration, second discal before two-thirds, connected by some irroration with costa, apex and tornus; a curved line of dots from three-fourths costa to tornus, submarginal except opposite apex; cilia ochreous-whitish. Hindwings and cilia grey-whitish.

Queensland: Rosewood in April; one specimen.

772. Eulechria molybdea, n. sp. (*μολυβδεος*, leaden.)

♀. 22 mm. Head and thorax pale metallic grey. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; grey. Antennae fuscous. Abdomen grey. Legs fuscous; posterior pair ochreous-whitish. Forewings suboblong, costa moderately arched, apex rounded, termen obliquely rounded; glossy whitish-grey; markings fuscous; a basal costal spot; a broad dorsal suffusion; first discal at one-third, plical beneath it, second discal at three-fifths, transversely crescentic; an additional dot immediately above and beyond first discal, connected by suffusion with midcosta; an inwardly oblique line from four-fifths costa, sharply angled outwards and inwards above middle to end on tornus; some fuscous suffusion precedes and follows this line; cilia grey, bases ochreous-whitish. Hindwings with 5 from middle; grey; cilia grey.

Peculiarly leaden-grey in colour. It is rather similar to *E. capnonota*, but the discal dots are differently placed.

Queensland: Mt. Tambourine in January; one specimen.

773. EULECHRIA NEPHELOSPILA, n. sp. (νεφελοσπιλος, with cloudy spots.)

♂. 23 mm. Head whitish. Palpi with second joint reaching base of antennae, terminal joint four-fifths; pale fuscous. Antennae grey; ciliations in male 1. Thorax pale grey. Abdomen grey; tuft ochreous-whitish. Legs fuscous; posterior pair whitish. Forewings slightly dilated, costa moderately arched, apex pointed, termen obliquely rounded; whitish-grey with some irroration and markings fuscous; a large sub-basal costal spot reaching fold; stigmata moderate with suffused irroration between and around; first discal at one-third, plical beyond it, elongate, second discal before two-thirds, a dot between and above discals, another larger and elongate above and beyond plical, a sixth beneath second discal, a large triangular spot on midcosta, its apex formed by fourth dot; a suffused circular blotch beyond second discal, connected with costa at four-fifths and with tornus; cilia whitish, on apex and costa grey. Hindwings with 5 from middle; pale grey; cilia pale grey.

Queensland: Mt. Tambourine in November; one specimen.

774. EULECHRIA EUALDES, n. sp. (εὐαλδης, well grown.)

♂, ♀. 30–34 mm. Head grey-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; pale fuscous, internal surface grey-whitish. Antennae grey, towards base grey-whitish; ciliations in male 1. Thorax grey-whitish, sometimes with fuscous irroration in centre. Abdomen grey-whitish; bases of segments grey, sometimes in basal segments ferruginous. Legs fuscous with grey-whitish rings; posterior pair mostly grey-whitish. Forewings suboblong, not dilated, costa strongly arched in basal fourth, thence straight, apex rounded, termen obliquely rounded; grey-whitish with markings and some irroration fuscous; a broad median band from costa, where it extends from base to one-fifth, to costa before apex, narrowing somewhat in disc, interrupted before apex; from apical part proceeds a fine curved line to tornus; a terminal series of dots; cilia grey-whitish, sometimes with obscure grey median bars. Hindwings rather broadly ovate; pale grey; cilia pale grey.

Easily recognized from its large size and broad longitudinal band of forewings.

North Queensland: Kuranda (one wasted female). Queensland: Toowoomba in September and October (two males). Type in Coll. Barnard.

775. EULECHRIA CRYPSIPYRRHA, n. sp. (κρυψιπυρρος, with hidden red.)

♀. 30 mm. Head and thorax dull reddish sprinkled with fuscous. Palpi with second joint exceeding base of antennae, terminal joint four-fifths; whitish sprinkled with fuscous, slightly reddish-tinged. Antennae pale reddish sprinkled with fuscous. Abdomen ochreous-fuscous with some whitish scales on apices of segments. Legs fuscous with whitish-ochreous rings. Forewings dilated, costa moderately arched, apex rounded, termen obliquely rounded; dull reddish with some fuscous irroration; stigmata obscure, fuscous, first discal at one-third, plical beneath it, second discal before two-thirds; cilia pale reddish with some fuscous points. Hindwings pale grey, towards base grey-whitish; cilia pale grey.

Queensland: National Park (3,000 feet) in November; one specimen received from Mr. W. B. Barnard.

776. EULECHRIA MUCIDA, n. sp. (*mucidus*, mouldy.)

♀. 26 mm. Head grey; face white. Palpi with second joint reaching base of antennae, shortly rough-scaled anteriorly throughout, terminal joint one-half,

slender, acute; white, extreme apex of terminal joint and a few scales elsewhere fuscous. Antennae grey. Thorax fuscous with white irroration. Abdomen grey. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings oval, costa strongly arched, apex obtusely pointed, termen oblique; whitish with dense even fuscous irroration appearing grey; markings fuscous; stigmata small, inconspicuous, first discal at one-fourth, plical larger, beneath it, second discal at two-thirds, a dot between and above discals, another before and beneath second discal; an obscure series of costal dots; a suffused line from four-fifths costa to tornus; subterminal submarginal and terminal series of dots; cilia grey. Hindwings with 5 from middle; pale grey; cilia pale grey.

The palpi are distinctive and peculiar, but not sufficiently so for the generic separation of a solitary species.

Queensland: Toowoomba in May; one specimen received from Mr. W. B. Barnard.

777. Eulechria scioessa, n. sp. (*σκιοεις*, darkly shaded.)

♀. 25–26 mm. Head fuscous mixed with ochreous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, apex and internal surface of second joint ochreous-whitish. Antennae, thorax, and abdomen fuscous. Legs fuscous; posterior pair whitish-ochreous. Forewings suboblong, not dilated, costa moderately arched, apex rounded, termen obliquely rounded; pale greyish-ochreous with fuscous irroration and markings; a basal costal spot; stigmata dark fuscous, first discal at one-third, plical beneath it, second discal before two-thirds, a dot shortly above and beyond first discal, another beneath second discal; a large suffused fuscous triangle before and touching two basal stigmata, extending on costa from one-fifth to three-fifths, its apex reaching fold; a thick line from four-fifths costa, at first inwardly oblique, then curved strongly outwards, and again inwards to tornus, its sinus more or less filled with fuscous, so as sometimes to form a large circular pale-centred spot; a terminal series of dots; cilia pale grey, bases pale greyish-ochreous more or less barred or suffused with fuscous. Hindwings and cilia grey.

Allied to *E. philostaura*.

Queensland: National Park (3,000–3,500 feet) in November and March; three specimens.

778. Eulechria euchlora Turn., *Tr.R.S.S.Aust.*, 1896, 12 (Brisbane, Tweed Hds., Bunya Mts.).

779. Eulechria philostaura Meyr., P.L.S.N.S.W., 1882, 537 (Eungella, Gympie to Kiama. Milmerran).

780. Eulechria baryptera Turn., *Tr.R.S.S.Aust.*, 1896, 11 (Cairns, Nambour, Brisbane, Toowoomba, Macpherson Range).

781. Eulechria umbrifera, n. sp. (*umbriferus*, shaded.)

♀. 26–27 mm. Head whitish sprinkled with fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous, base, apex, and inner surface of second joint, and base of terminal joint, whitish. Antennae fuscous. Thorax fuscous with a few whitish scales. Abdomen ferruginous; apices of segments pale grey. Legs fuscous with whitish rings; posterior pair ochreous-whitish. Forewings rather broad, costa strongly arched especially towards base, apex rounded, termen slightly oblique; whitish with general fuscous irroration and markings; an oblique line from near base of costa to fold; first discal at one-third, plical slightly beyond it, second discal before two-thirds, a dot above and beyond discals, another just above and beyond or confluent with plical, a sixth

beneath second discal; suffused costal spots on middle and three-fourths; dorsal spots on middle and tornus; sometimes these are suffusedly connected with costal spots to form transverse fasciae; a subterminal line; some terminal dots; cilia whitish, bases barred with fuscous, apices pale grey. Hindwings from middle or slightly above; grey-whitish; cilia whitish.

Queensland: National Park (3,500 feet) in December; two specimens.

782. EULECHRIA CAPNONOTA, n. sp. (*καπνονωτος*, with smoky dorsum.)

♂. 20–25 mm. Head pale grey. Palpi with second joint somewhat exceeding base of antennae, terminal joint three-fourths; fuscous, inner surface whitish. Antennae grey; ciliations in male one-half. Thorax grey-whitish; anterior edge broadly fuscous. Abdomen grey; bases of segments ferruginous, tuft whitish-ochreous. Legs fuscous; posterior pair grey-whitish. Forewings suboblong, costa strongly arched near base, thence moderately, apex rounded, termen very obliquely rounded; grey-whitish; markings and slight irroration dark fuscous; a small blotch on dorsum from one-fourth to middle; first discal at one-third, plical beyond it, second discal before two-thirds, a dot above and between discals, another slightly beyond and beneath first discal, a sixth above and beyond plical, a seventh below second discal, usually confluent forming a crescentic mark; a line from three-fourths costa obliquely outwards, then angled and sinuate to tornus; a terminal series of dots; cilia whitish with an antemedian series of grey bars. Hindwings with 5 from middle; grey; cilia grey.

Queensland: Mt. Tambourine in November; Toowoomba in December. New South Wales: Brunswick Hds. in December and January. Eight specimens. Type in Coll. Barnard.

783. EULECHRIA PERCNA, n. sp. (*περκνος*, dark.)

♂. 22 mm. Head and thorax fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous. Antennae grey; ciliations in male two-thirds. Abdomen grey. Legs fuscous; posterior pair pale grey. Forewings narrowly oval, costa strongly arched, apex pointed, termen extremely oblique; grey; markings and some irroration blackish; a broad oblique streak from costa near base to fold; first discal at one-fourth, plical scarcely beyond it, second discal at three-fifths, a dot between and above discals, another before and below second discal; sometimes costal spots at one-fourth and middle, the former sometimes confluent with first discal; an inwardly oblique line from three-fourths costa, soon sharply angled outwards, thence strongly curved to tornus; some terminal dots; cilia fuscous barred with whitish, apices grey. Hindwings with 5 from middle; grey; cilia grey.

Near *E. amaura*, but forewings paler without general fine fuscous irroration, markings blackish and much more conspicuous, especially the costal spots.

Queensland: Stanthorpe in January; four specimens received from Mr. W. B. Barnard, who has the type.

784. EULECHRIA PHLAURA, n. sp. (*φλαυρος*, shabby.)

♂. 20–22 mm. Head whitish-grey. Palpi with second joint reaching base of antennae, terminal joint four-fifths; whitish-grey. Antennae whitish-grey; ciliations in male one-half. Thorax whitish-grey with slight fuscous irroration. Abdomen whitish-grey; bases of median segments ferruginous. Legs whitish; anterior pair fuscous. Forewings suboval, costa strongly arched, apex rounded, termen obliquely rounded; whitish-grey with some fuscous irroration and markings; a suffused narrow fascia from one-fifth costa to mid-dorsum; first discal at one-third, plical lost in fascia, second discal slightly beyond middle, a dot between and above

discals, another before and below second discal; a suffused spot on midcosta; a line from five-sixths costa, at first inwardly oblique, soon angled outwards, strongly curved, and sinuate to tornus; a terminal series of short obscure streaks on veins; cilia grey-whitish, bases grey. Hindwings with 5 from middle; grey; cilia grey.

Queensland: Brisbane in January and April; two specimens.

785.† Eulechria mochlastis Meyr., P.L.S.N.S.W., 1887, 960 (Albany, W.A.).

786. Eulechria siccella Wlk., xxix, 643; Meyr., P.L.S.N.S.W., 1882, 544 (Brisbane to Melbourne. Mt. Lofty. Busselton, Waroona, W.A.).

787.† Eulechria hiemalis Meyr., *Exot. Micro.*, i, 218 (Sydney).

788. Eulechria grammatica Meyr., P.L.S.N.S.W., 1882, 545 (Tweed Hds., to Sydney. Toowoomba to Mittagong).

789. Eulechria gypsochyta, n. sp. (*γυψοχυτος*, smeared with chalk.)

♂. 22 mm. Head grey-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous, apex of second joint whitish. Antennae grey; ciliations in male 2½. Thorax grey; anterior edge fuscous. Abdomen pale ochreous-grey; bases of segments ferruginous. Legs grey; posterior pair ochreous-whitish. Forewings narrowly oval, costa moderately arched, apex round-pointed, termen obliquely rounded; whitish sparsely and unevenly sprinkled with fuscous, more densely towards margins, costal edge dark fuscous towards base; a fuscous subcostal dot near base, and another on one-sixth costa; stigmata approximated, small, dark fuscous, first discal at one-third, plical beyond it, second discal at three-fifths, a dot above and between discals, nearer the first, another beneath second discal, a sixth below and before this; a suffused inwardly oblique streak from four-fifths costa, angled outwards and continued as a curved line to tornus; a terminal series of dots; cilia grey. Hindwings with 5 from below middle; grey; cilia grey.

North Queensland: Kuranda in September; one specimen received from Mr. W. B. Barnard.

790.† Eulechria themerodes Meyr., *Tr.R.S.S.Aust.*, 1902, 152 (Gisborne).

791.† Eulechria leucocrossa Meyr., P.L.S.N.S.W., 1888, 1583 (Carnarvon, W.A.).

792. Eulechria tephropolia, n. sp. (*τεφροπολιος*, ashen-grey.)

♂. 20–24 mm. Head and thorax grey. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; grey, base and extreme apex of second joint whitish. Antennae grey; ciliations in male 1. Abdomen whitish-grey; bases of proximal segments ferruginous. Legs grey-whitish; anterior pair fuscous. Forewings narrow, costa rather strongly arched, apex pointed, termen oblique; pale grey; markings and some scanty irroration dark fuscous; first discal at one-third, plical slightly beyond, second discal at two-thirds, sometimes double, a dot above and between discals; a line of dots from four-fifths costa obliquely outwards to near apex, there sharply angled and continued to tornus; some terminal dots; cilia whitish-grey. Hindwings and cilia whitish-grey.

Western Australia: Perth; four specimens received from Mr. J. Clark.

793. Eulechria pelina, n. sp. (*πηλινος*, clay-coloured.)

♂. 23 mm. Head and thorax fuscous-brown. Palpi with second joint exceeding base of antennae, terminal joint one-half; pale fuscous, apex of second joint whitish. Antennae grey; ciliations in male 1. Abdomen ochreous-whitish. Legs fuscous; posterior pair ochreous-whitish. Forewings elongate, costa gently arched, apex rounded, termen obliquely rounded; brown with fine fuscous irroration; stigmata approximated, fuscous, first discal at one-third, plical beneath it, second discal at

three-fifths, a dot above and between discals; cilia whitish-brown with some fuscous points. Hindwings and cilia ochreous-whitish.

Western Australia: Ooldea in July; one specimen received from Mr. J. E. Kershaw.

794. Eulechria torvella, n. sp. (*torvellus*, small, gloomy.)

♂. 14–15 mm. Head and thorax fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fifths; fuscous. Antennae fuscous; ciliations in male one-half. Abdomen grey; tuft ochreous-whitish. Legs fuscous with whitish rings; posterior pair grey with broad ochreous-whitish rings. Forewings narrow, slightly dilated, costa slightly arched, apex rounded, termen very obliquely rounded; pale fuscous sprinkled with dark fuscous; markings obscure, dark fuscous; first discal at one-third, second discal at middle, plical obsolete; a spot on costa beyond middle; a large triangular apical spot prolonged on termen to tornus; cilia fuscous. Hindwings and cilia pale grey.

Queensland: Bunya Mts. in November and December; four specimens.

795. Eulechria xanthocephala Low., *Tr.R.S.S.Aust.*, 1883, 177 (Adelaide).

796. Eulechria synaptospila, n. sp. (*συναπτοσπιλος*, with joined spots.)

♂. 15–16 mm. Head and thorax ochreous-whitish. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; ochreous-whitish with fuscous irroration. Antennae grey; ciliations in male very short (one-third). Abdomen grey; tuft ochreous-whitish. Forewings suboblong, slightly dilated, costa arched near base, thence straight, apex rounded, termen slightly oblique; ochreous-whitish with fuscous markings; a large basal suffusion extending to one-third; first discal at one-third, plical before it, second discal before two-thirds; a suffused fuscous streak from first discal through second discal to apex; a suffused spot on two-thirds costa; a small apical suffusion; cilia whitish partly suffused with fuscous. Hindwings whitish with slight grey suffusion towards apex; cilia whitish.

Queensland: Brisbane and Tweed Hds. in September; two specimens.

797. Eulechria oenoessa, n. sp. (*οἰνοεσσος*, wine-stained.)

♂. 15–18 mm. Head and thorax dull pink sprinkled with fuscous. Palpi with second joint reaching base of antennae, slightly rough anteriorly, terminal joint one-half; dull pink sprinkled with fuscous. Antennae dull pink sprinkled with fuscous; ciliations in male 2. Abdomen pinkish-ochreous; apices of segments and tuft ochreous-whitish. Legs pinkish barred or ringed with fuscous; posterior pair ochreous-whitish. Forewings narrow, suboblong, costa slightly arched, apex rounded, termen obliquely rounded; dull pink sprinkled with fuscous; markings dark fuscous; first discal at two-fifths, plical beneath or scarcely beyond it, second discal at three-fifths; an evenly curved subterminal line or series of dots from four-fifths costa to tornus; cilia dull pink with a few fuscous points. Hindwings and cilia ochreous-grey-whitish.

Queensland: Brisbane in October and April; three specimens.

798. Eulechria haemopa, n. sp. (*αἱμωπος*, blood-stained.)

♂. 15–20 mm. Head fuscous sprinkled with pale reddish; face whitish. Palpi with second joint reaching base of antennae, terminal joint two-thirds; pale reddish, terminal joint fuscous. Antennae fuscous; ciliations in male scarcely one-half. Thorax pale reddish sprinkled with fuscous. Abdomen pale grey. Legs fuscous with whitish rings; posterior pair whitish. Forewings narrowly oval, costa gently arched, apex rounded, termen very obliquely rounded; pale reddish sprinkled with dark fuscous, more so towards margins; markings dark fuscous; a dot on base of costa confluent with a suffused sub-basal dorsal patch; first discal

at one-third, plical beneath or beyond, second discal before two-thirds, suffusedly connected with costa; a large subapical spot connected by a submarginal line with tornus; cilia pale fuscous. Hindwings and cilia grey-whitish.

Queensland: Brisbane in November; Stanthorpe in December; two specimens.

799. EULECHRIA RHODOBAPTA, n. sp. (ῥοδοβαπτος, rosy-tinged.)

♂. 19 mm. Head pale fuscous. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; ochreous-whitish, external surface of second joint with basal half and a subapical bar fuscous, terminal joint except apex fuscous. Antennae fuscous; in male slightly serrate, ciliations two-thirds. Thorax whitish-grey; anterior margin fuscous. Abdomen brownish; apices of segments whitish-grey; tuft whitish-ochreous. Legs fuscous with whitish-ochreous rings; posterior pair mostly whitish-ochreous. Forewings somewhat dilated, costa moderately arched, apex rounded, termen obliquely rounded; ochreous-whitish tinged with pale rosy and sprinkled with fuscous; stigmata dark fuscous, first discal at one-fourth, plical beneath it, second discal in middle; a pale bar connecting discals and a pale spot beneath second; a dark fuscous inwardly oblique suffused line from costa before apex, sharply angled inwards, and again outwards, and continued parallel to termen; between this and termen a series of pale rosy-tinged dots; cilia fuscous, apical half fuscous bisected by a pale grey line. Hindwings grey; cilia grey-whitish.

Queensland: Brisbane; National Park (2,500 feet) in open forest in November; two specimens.

800. EULECHRIA PHAEOMOCHLA, n. sp. (*φαιομοχλος*, with dusky bars.)

♂. 16–18 mm. Head and thorax fuscous. Palpi with second joint just reaching base of antennae, terminal joint three-fifths; pale fuscous. Antennae fuscous; ciliations in male one-half. Forewings narrow, slightly dilated, costa gently arched, apex rounded, termen obliquely rounded; whitish-fuscous; markings dark fuscous; a narrow basal fascia; first discal at one-third, plical beneath it, these are connected by some suffusion with each other and margins to form an incomplete narrow fascia; second discal before two-thirds, connected with costa just beyond middle and with tornus to form a second fascia; a third and broader fascia from four-fifths costa narrowing to a point above tornus; cilia whitish-fuscous with dark fuscous points. Hindwings elongate-ovate; 5 from middle; grey; cilia grey.

Victoria: Castlemaine in March (Dr. W. E. Drake); two specimens. Type in National Museum, Melbourne.

801. EULECHRIA ACLITA, n. sp. (*ἀκλειτος*, inglorious.)

♂. 17–18 mm. Head and thorax fuscous-brown. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; brown-whitish sprinkled with fuscous. Antennae fuscous-brown; ciliations in male 1. Abdomen pale ochreous; apices of segments and tuft ochreous-grey-whitish. Legs fuscous with ochreous-whitish rings. Forewings narrow, posteriorly dilated, costa rather strongly arched, apex rounded, termen obliquely rounded; pale brown sprinkled with fuscous; markings dark fuscous; first discal at one-fourth, plical slightly beyond it, second discal in middle; a suffused spot on tornus connected with second discal; an indistinct suffused fascia from four-fifths costa to tornus; cilia grey-whitish with some fuscous points. Hindwings with 5 from middle; grey-whitish; cilia grey-whitish.

Western Australia: Denmark in March; two specimens received from Mr. W. B. Barnard, who has the type.

802. Eulechria micranepsia, n. sp. (*μικρανεψιος*, a small cousin.)

♂. 11 mm. Head, thorax, and abdomen ochreous-grey-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fourths; whitish, outer surface of second joint except apex fuscous. Antennae pale grey; ciliations in male 1. Legs fuscous; posterior pair grey-whitish. Forewings narrow, suboval, costa slightly arched, apex round-pointed, termen very oblique; ochreous-grey-whitish with blackish dots; first discal at one-third, plical beneath it, second discal before two-thirds; a series of minute dots close to margin from costa before middle to tornus; cilia concolorous. Hindwings and cilia grey-whitish.

Very like *E. stigmatophora*, but much smaller and the antennal ciliations much shorter (in the latter 2½).

Queensland: Caloundra in October; one specimen.

803. Eulechria indecora, n. sp. (*indecorus*, unbecoming.)

♂. 15 mm. Head brownish. Palpi with second joint reaching base of antennae, terminal joint three-fourths; brown-whitish, outer surface of second joint densely sprinkled with fuscous, terminal joint wholly fuscous. Antennae fuscous; ciliations in male one-half. Thorax fuscous. Abdomen grey. Legs fuscous; posterior pair ochreous-whitish. Forewings narrow, oblong, costa slightly arched, apex rounded, termen obliquely rounded; brownish-fuscous; stigmata obscurely darker, small, first discal at two-fifths, plical beneath it, second discal at three-fifths; cilia fuscous. Hindwings whitish, towards apex pale grey; cilia whitish.

Queensland: Mt. Tambourine in November; one specimen.

804. Eulechria ochrophaea Meyr., P.L.S.N.S.W., 1883, 361 (Cairns to Tasmania).

805. Eulechria episema Meyr., ibid., 1882, 517 (Victoria. Mt. Lofty. Denmark, W.A.).

806. Eulechria photinopis Low., ibid., 1900, 40 (Broken Hill).

807. Eulechria melesella Newm., *Tr.E.S.* (2) iii, 291; Meyr., P.L.S.N.S.W., 1882, 516 (Victoria. Hobart).

808.† Eulechria aphaura Meyr., ibid., 1887, 946 (Sydney).

809.† Eulechria anadesma Meyr., ibid., 1888, 1579 (Sale, V.).

810. Eulechria phaeopepla, n. sp. (*φαιοπεπλος*, in dusky clothing.)

♂. 20 mm. Head ochreous-grey-whitish. Palpi with second joint exceeding base of antennae, twice length of face, stout and rough anteriorly, terminal joint three-fifths; fuscous, extreme apex and inner surface of second joint whitish. Antennae fuscous; ciliations in male one-half. Thorax fuscous. Abdomen grey. Legs fuscous with whitish tarsal rings; posterior tibiae grey-whitish. Forewings dilated, costa moderately arched, apex rounded, termen obliquely rounded; grey with markings and some irroration fuscous; discals approximated, first at one-third, plical beneath it, second at three-fifths; an inwardly oblique streak from five-sixths costa, angled outwards above middle, and thence outwardly curved to tornus; cilia pale grey with a broad interrupted fuscous basal line. Hindwings and cilia whitish-grey.

New South Wales: Mittagong in January; one specimen.

811. Eulechria zoropa, n. sp. (*ζωρωπος*, unmixed.)

♂. 24 mm. Head and thorax white. Palpi with second joint exceeding base of antennae, twice length of face, terminal joint four-fifths; whitish. Antennae whitish, towards apex grey; ciliations in male shortly over 1. Abdomen pale grey; apices of segments and tuft whitish. Legs ochreous-whitish. Forewings oblong, costa arched near base, thence straight, apex rounded, termen rounded,

slightly oblique; white; costal edge near base dark fuscous; cilia white. Hindwings grey; cilia whitish.

Larger and broader-winged than *E. pacifera*, the palpi much longer.

Queensland: Palm Is. in June; one specimen.

812. EULECHRIA LIQUIDA Meyr., *Exot. Micro.*, i, 164 (Cairns, Atherton, Townsville).

813. EULECHRIA CERATOCHROA Low., *Tr.R.S.S.Aust.*, 1920, 60 (Toowoomba to Gisborne and Birchip).

814. EULECHRIA HOLODASCIA, n. sp. (ὁλοδασκιος, wholly dark.)

♂. 22–24 mm.; ♀. 30–34 mm. Head and thorax fuscous-brown. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; brownish. Antennae pale grey; ciliations in male 1½. Abdomen fuscous. Legs brown-whitish. Forewings suboblong, costa moderately arched, apex rounded, termen obliquely rounded; fuscous-brown; stigmata minute, fuscous, first discal at two-fifths, second at three-fifths, plical obsolete, in female all may be obsolete; cilia fuscous. Hindwings and cilia fuscous.

Not unlike *E. acropenthes*, but the forewings are not dilated, the hindwings darker, and the antennae in the male stouter with longer ciliations.

Queensland: Yeppoon in December (E. J. Dumigan); Westwood in November (G. M. Goldfinch); four specimens.

815. EULECHRIA PLINTHOCHROA, n. sp. (πλινθοχροος, brick-coloured.)

♀. 32 mm. Head and thorax reddish-grey. Palpi with second joint reaching base of antennae, terminal joint three-fourths; reddish-grey. Antennae grey. Abdomen grey, reddish-tinged. Legs reddish-grey. Forewings suboblong, costa nearly straight, apex rounded-rectangular, termen slightly rounded, slightly oblique; reddish-grey; stigmata minute, blackish, first discal at one-third, plical scarcely beyond it, second discal at three-fifths; cilia reddish-grey. Hindwings and cilia grey.

North Queensland: Herberton in September; one specimen.

816. EULECHRIA PUNICEA, n. sp. (*puniceus*, pink.)

♂. 22 mm. Head and thorax pale pink. Palpi with second joint reaching base of antennae, terminal joint four-fifths; pale pink. Antennae pinkish-grey; ciliations in male 2. Abdomen grey. Legs fuscous; posterior pair ochreous-whitish. Forewings narrow, strongly dilated, costa nearly straight, but arched towards apex, apex rounded, termen obliquely rounded; 2 from well before angle remote from 3; pale pink sparsely sprinkled with grey; stigmata grey, suffused, first discal at one-third, plical before it, second discal before two-thirds; cilia pale pink. Hindwings and cilia pale grey.

South Australia: Ooldea in August (Nicholson); one specimen. Type in Coll. Goldfinch.

817. EULECHRIA HAPLOPEPLA, n. sp. (ἁπλοπεπλος, simply clothed.)

♂. 25 mm. Head and thorax pale grey, palpi with terminal joint one-half; grey, terminal joint whitish-grey. Antennae grey; ciliations in male 2. Abdomen ochreous-grey-whitish with some transverse brown bars on dorsum. Legs grey; posterior pair grey-whitish. Forewings suboblong, not dilated, costa strongly arched, apex rounded-rectangular, termen rounded, slightly oblique; whitish-grey; stigmata small, blackish, first discal about one-third, plical slightly beyond it, second discal about middle; subterminal line represented by a few blackish scales; cilia whitish-grey. Hindwings and cilia grey-whitish.

New South Wales: Barrington Tops in December; two specimens received from Mr. G. M. Goldfinch, who has the type.

818. EULECHRIA GRISEOLA Zel., *Lin. Ent.*, x, 151; Meyr., P.L.S.N.S.W., 1882, 512 (= *drosocapna* Meyr., *Exot. Micro.*, ii, 373) (Duaringa to Melbourne. Mt. Lofty).

819. EULECHRIA DYSIMERA, n. sp. (δυσιμερος, undesired.)

♂. 25 mm. Head and thorax fuscous-grey. Palpi with second joint thickened and rough anteriorly, exceeding base of antennae, terminal joint two-thirds; fuscous-grey. Antennae fuscous-grey; ciliations in male 2. Abdomen grey; bases of segments ferruginous. Legs fuscous-grey; posterior pair ochreous-grey-whitish. Forewings suboblong, costa gently arched, apex rounded, termen obliquely rounded; fuscous-grey; markings and some scattered scales fuscous; a small suffused basal patch; first discal at one-third, plical beneath it, second discal before two-thirds; some fuscous suffusion between second discal and tornus; a series of obscure dots from two-thirds costa obliquely outwards, then curved inwards towards tornus; a more distinct submarginal line connected by fine streaks with termen; cilia grey. Hindwings and cilia grey.

Queensland: Chinchilla in October; one specimen.

820.† EULECHRIA NOMISTIS Meyr., P.L.S.N.S.W., 1888, 1579 (Perth, Geraldton, W.A.).

821.† EULECHRIA ARGOLINA Meyr., ibid., 1888, 1578 (Albany, W.A.).

822.† EULECHRIA MENODES Meyr., ibid., 1887, 945 (Geraldton, W.A.).

823. EULECHRIA CREMNODES Meyr., ibid., 1882, 514 (Mt. Tambourine to Victoria. Mt. Lofty. Waroona, W.A.).

824. EULECHRIA ACROPENTHES, n. sp. (ἀκροπενθης, very mournful.)

♂. 24 mm. Head, thorax and abdomen fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous. Antennae fuscous; ciliations in male 1. Legs fuscous; posterior pair ochreous-grey-whitish. Forewings dilated, costa moderately arched, apex rounded, termen rounded, slightly oblique; fuscous; stigmata dark fuscous, minute, first discal at one-fourth, plical beneath it, second discal in middle; slight indications of a darker subterminal line; cilia fuscous. Hindwings and cilia grey.

Queensland: Crow's Nest, near Toowoomba, in October; one specimen.

825. EULECHRIA PELODORA Meyr., P.L.S.N.S.W., 1887, 944 (Gisborne, Mt. Lofty).

826. EULECHRIA PUBLICANA Meyr., *Exot. Micro.*, i, 168 (Waroona, W.A.).

827.† EULECHRIA NEPHELOPA Meyr., P.L.S.N.S.W., 1882, 513 (Sydney).

828.† EULECHRIA HELICTIS Meyr., ibid., 1888, 1584 (Albany, Perth, W.A.).

829. EULECHRIA MYRIOSPILA Low., *Tr.R.S.S.Aust.*, 1903, 222 (= *metata* Meyr., *Exot. Micro.*, i, 168; = *ethnitis* Meyr., ibid., ii, 384) (Glen Innes to Tasmania. Mt. Lofty).

830. EULECHRIA DELOTIS Meyr., P.L.S.N.S.W., 1887, 952 (Brisbane, Toowoomba. Miles, Murrurundi, Sydney. York, W.A.).

831. EULECHRIA DYSAETHRIA, n. sp. (δυσαιθριος, not clear.)

♀. 28 mm. Head whitish-grey. Palpi with second joint much exceeding base of antennae, terminal joint four-fifths; fuscous, apex of second joint white. Antennae pale grey. Thorax fuscous. Abdomen pale grey; bases of segments ferruginous. Legs fuscous; anterior tibiae with whitish rings; posterior pair grey-whitish. Forewings dilated, costa slightly arched, apex rounded-rectangular, termen slightly oblique; whitish with uniform fine fuscous irroration, appearing grey; stigmata minute, fuscous, first discal at one-fourth, plical beneath it, second discal at one-half, a dot midway between and above discals; a very fine fuscous

line from beneath four-fifths costa outwards, then bent and subterminal to tornus; cilia grey-whitish with fuscous points. Hindwings with 5 from middle; grey-whitish; cilia grey-whitish.

Queensland: Toowoomba in August; one specimen received from Mr. W. B. Barnard.

832. Eulechria atmospila Turn., P.L.S.N.S.W., 1916, 360 (Toowoomba to Sydney).

833. Eulechria botryospila, n. sp. (*βοτρυοσπιλος*, with clustered spots.)

♀. 20 mm. Head, thorax, and abdomen whitish-grey. Palpi slender, second joint much exceeding base of antennae, 2½ times length of face, terminal joint two-thirds; whitish. Antennae grey-whitish. Legs whitish. Forewings narrow, slightly dilated, costa gently arched, apex pointed, termen oblique; whitish-grey with blackish dots; a series of minute subcostal dots from base to middle; a circular cluster above tornus, more or less confluent; numerous minute dots irregularly dispersed in disc; a terminal series of dots; cilia whitish-grey. Hindwings and cilia whitish.

Tasmania: Deloraine in February; one specimen.

834. Eulechria virgata, n. sp. (*virgatus*, striped.)

♂. 22 mm. Head and thorax grey. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; fuscous, second joint with internal surface pale grey, apex whitish. Antennae grey; ciliations in male 1¾. Legs fuscous; posterior pair whitish-grey. Forewings dilated posteriorly, costa slightly arched, apex round-pointed, termen obliquely rounded; grey with fuscous markings; a fine subcostal line nearly to middle; a similar longitudinal line in cell; first discal at one-third, plical beyond it, second discal before two-thirds; a line from second discal nearly to apex; a subdorsal line in middle third; a large circular supratornal spot; some short streaks on veins; a subterminal series of dots from beneath apex to tornus; cilia grey with a broad fuscous median line. Hindwings with 5 from below middle; grey, darker than forewings; cilia grey.

Western Australia: Denmark in March; one specimen received from Mr. W. B. Barnard.

835. Eulechria isopsepha Meyr., *Exot. Micro.*, i, 158 (Gisborne, Lorne. Mt. Gambier).

836.† Eulechria ephalta Meyr., ibid., i, 299 (Mt. Kosciusko).

837.† Eulechria autographa Meyr., *Tr.R.S.S.Aust.*, 1902, 152; *Exot. Micro.*, i, 307 (Sydney).

838.† Eulechria diagramma Meyr., P.L.S.N.S.W., 1887, 961 (Albany, W.A.).

839. Eulechria melanogramma Turn., ibid., 1916, 364 (Yeppoon, Brisbane, Toowoomba).

840. Eulechria spilophracta, n. sp. (*σπιλοφρακτος*, with spotted border.)

♂. 19–21 mm. Head grey-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous, apices of second and terminal joints whitish. Antennae fuscous; ciliations in male 1. Thorax fuscous with a posterior whitish spot. Abdomen grey; bases of segments ferruginous. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings suboblong, costa rather strongly arched, apex rounded, termen obliquely rounded; whitish densely sprinkled with fuscous, appearing grey; markings fuscous; a large basal spot; first discal at one-third, plical beneath it, sometimes connected with basal spot, second discal at three-fifths, a whitish streak between discals; a submarginal series of dots from before midcosta to mid-dorsum, on costa separated and on termen succeeded by whitish dots; cilia fuscous with whitish bars, apices whitish.

Queensland: Maryland near Stanthorpe in December; two specimens received from Mr. W. B. Barnard, who has the type.

841.† Eulechria homospora Meyr., *Exot. Micro.*, i, 158 (Mt. Kosciusko).

842. Eulechria stadiota Meyr., P.L.S.N.S.W., 1888, 1580 (Albany, Denmark, Busselton, W.A.).

843. Eulechria zophoptera, n. sp. (ζοφοπτερος, dark-winged.)

♂. 18–20 mm.; ♀. 25 mm. Head and thorax dark fuscous. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous. Antennae fuscous; ciliations in male 2. Abdomen dark fuscous. Legs fuscous with whitish rings; posterior pair mostly whitish. Forewings suboval, costa moderately arched, apex rounded, termen obliquely rounded; grey densely sprinkled with dark fuscous; markings dark fuscous, obscure; first discal at two-fifths, plical beneath it, second discal at three-fifths; a subterminal line from beneath two-thirds costa to tornus, evenly curved; cilia fuscous with narrow bars. Hindwings dark grey, in male brownish-tinged; cilia grey with a darker sub-basal line.

Queensland: Milmerran in March; three specimens received from Mr. J. Macqueen.

844.† Eulechria infestata Meyr., *Exot. Micro.*, i, 166 (Darwin).

845. Eulechria orbitosa Meyr., ibid., ii, 373 (Gisborne).

846. Eulechria empheres, n. sp. (ἐμφερης, similar.)

♂, ♀. 20–24 mm. Head and thorax fuscous-brown. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous-brown. Antennae fuscous-brown; ciliations in male 3. Abdomen grey; bases of segments sometimes ferruginous. Legs fuscous with ochreous-whitish rings; posterior pair ochreous-whitish. Forewings suboblong, costa slightly arched, apex rounded, termen obliquely rounded; fuscous-brown with dark fuscous irroration forming streaks on veins; markings dark fuscous; first discal at one-third, plical beyond it, second discal before two-thirds; a submarginal series of dots from costa before middle around apex and termen to tornus, not indented; cilia pale grey with a fuscous sub-basal line. Hindwings with 5 from below middle; pale grey; cilia pale grey with a basal ochreous-whitish line.

Closely similar to *E. orbitosa*, but more heavily infuscated and the discals not so closely approximated; certainly distinct by the longer antennal ciliations (in *orbitosa* 1½).

Queensland: Toowoomba in November, December and January; five specimens received from Mr. W. B. Barnard, who has the type.

847. Eulechria delospila Turn., P.L.S.N.S.W., 1916, 363 (Stanthorpe).

848. Eulechria isotima, n. sp. (ἰσοτιμος, equally honoured.)

♂. 19–25 mm. Head and thorax grey. Palpi with second joint reaching base of antennae, terminal joint four-fifths; whitish-grey. Antennae grey; ciliations in male 1½. Abdomen grey; bases of segments sometimes ferruginous. Legs grey; posterior pair grey-whitish. Forewings suboval, costa rather strongly arched, apex rounded, termen obliquely rounded; pale ochreous-grey; markings dark fuscous, distinct; basal dots on costa and dorsum and a median dot near base; stigmata large, first discal scarcely beyond one-fourth, plical beyond it, second discal slightly beyond middle; a submarginal series of dots from costa before middle around apex and termen to tornus, the dot opposite apex slightly displaced inwards; a small fuscous suffusion between second discal and tornus; cilia grey. Hindwings with 5 from much below middle; pale grey; cilia pale grey.

Similar to *E. delosticta* from the same locality, but that species has no ochreous tinge in forewings, the basal dots are much less distinct, there is a pretornal marginal dot, and costal dots are marginal.

Queensland: Stanthorpe in December, February and March; seven specimens received from Mr. W. B. Barnard, who has the type.

849. EULECHRIA LISSOPHANES, n. sp. (*λισσοφανης*, smooth.)

♂. 22–23 mm. Head and thorax grey. Palpi with second joint much exceeding base of antennae, terminal joint three-fifths; grey. Antennae grey; ciliations in male 1. Abdomen brown; apices of segments and tuft pale grey. Legs grey. Forewings strongly dilated, costa moderately arched, apex pointed, termen obliquely rounded; pale grey with sparse fuscous irroration and markings; stigmata small, first discal at one-fourth, plical slightly beyond it, second discal about middle; some ill-defined streaks of fuscous suffusion between veins and beneath basal third of costa; a series of dots from beneath two-thirds costa, indented at apex, very near termen to tornus; cilia pale grey. Hindwings and cilia ochreous-whitish.

New South Wales: Barrington Tops in December; three specimens received from Mr. G. M. Goldfinch, who has the type.

850. EULECHRIA THETICOPHARA, n. sp. (*θητικοφαρος*, in menial garb.)

♂. 22–24 mm. Head and thorax grey. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; grey. Antennae fuscous; ciliations in male 3. Abdomen brownish-fuscous; apices of segments pale grey. Legs fuscous; posterior pair ochreous-whitish. Forewings suboblong, slightly dilated, costa moderately arched, apex rounded, termen obliquely rounded; grey with dark fuscous markings; first discal at one-third, plical beneath it, second discal before two-thirds; a subterminal line from beneath two-thirds costa to tornus, indented opposite apex; cilia grey. Hindwings and cilia pale grey.

Queensland: Milmerran in November; four specimens received from Mr. J. Macqueen.

851. EULECHRIA RHYMODES Meyr., *Exot. Micro.*, i, 165 (Cairns to Allyn R., N.S.W.).

852. EULECHRIA HYPNOTIS Meyr., P.L.S.N.S.W., 1888, 1583 (Denmark, Geraldton, W.A.).

853. EULECHRIA CYCNODES Meyr., ibid., 1888, 1582 (Perth, W.A.).

854.† EULECHRIA AUTOPHYLLA Meyr., ibid., 1887, 947 (Carnarvon, W.A.).

855. EULECHRIA TYRODES, n. sp. (*τυρωδης*, cheese-coloured.)

♂. 17 mm. Head and thorax ochreous-yellow. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; fuscous, terminal joint and apex of second joint whitish-ochreous. Antennae grey; ciliations in male 1½. Abdomen grey; tuft whitish-ochreous. Legs fuscous; posterior pair whitish-ochreous. Forewings suboval, costa moderately arched, apex rounded, termen obliquely rounded; ochreous-yellow; costal edge blackish towards base; cilia ochreous-yellow on tornus dark grey. Hindwings grey; cilia grey or pale ochreous.

Near *E. monoides*, but in that species the palpi are wholly yellowish and shorter, the second joint barely reaching base of antennae, and the cilia of forewings are wholly ochreous-yellow.

New South Wales: Allyn River in December; two specimens received from Mr. G. M. Goldfinch, who has the type.

856. EULECHRIA MONOIDES Turn., *Tr.R.S.S.Aust.*, 1917, 74 (Toowoomba, Bunya Mts., Glen Innes, Guyra, Ebor).

857. EULECHRIA HOMOCHROA Turn., P.L.S.N.S.W., 1916, 361 (Townsville to Sydney).

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858. EULECHRIA EXANIMIS Meyr., ibid., 1882, 519 (Stradbroke Is. Tweed Hds., Sydney. Melbourne).

859. EULECHRIA CORSOTA Meyr., *Exot. Micro.*, i, 164 (= *threnodes* Turn., P.L.S.N.S.W., 1916, 361; = *catharistis* Turn., ibid., 1916, 361) (Cooktown to Tabulam, N.S.W.).

I make the antennal ciliations 1½ to 1¾, not 1 as given by Meyrick. The species may be distinguished from *E. pallidella* by the grey hindwings, which vary much in darkness of tinge, and by the shorter, proportionately broader forewings with rounded apices. Occasionally the thorax and forewings are greyish.

860. EULECHRIA CNECOCROSSA, n. sp. (κνηκοκροσσος, yellowish-edged.)

♂. 20 mm. Head and thorax whitish, yellowish-tinged. Palpi with second joint reaching base of antennae, terminal joint three-fourths; whitish, anterior margin of terminal joint fuscous. Antennae pale grey; ciliations in male 1. Abdomen whitish-ochreous. Legs whitish-ochreous; anterior pair pale fuscous. Forewings suboval, costa rather strongly arched, apex rounded, termen obliquely rounded; whitish, yellowish-tinged, more so towards termen; cilia whitish, yellowish-tinged. Hindwings grey, cilia whitish, yellowish-tinged.

Queensland: Duaringa in November; one specimen received from Mr. W. B. Barnard.

861. EULECHRIA PHOENISSA Meyr., *Tr.R.S.S.Aust.*, 1902, 147 (Duaringa, Milmerran).

862. EULECHRIA XUTHOPTILA, n. sp. (ξουθοπτιλος, tawny-winged.)

♂. 15–18 mm. Head orange-ochreous. Palpi with second joint just reaching base of antennae, terminal joint four-fifths; ochreous, basal half of external surface of second joint fuscous. Antennae fuscous, ciliations in male slightly over 1. Thorax fuscous; apices of tegulae and a posterior spot ochreous. Abdomen pale ochreous-grey. Legs fuscous, posterior pair pale ochreous. Forewings rather narrow, strongly dilated, costa gently arched, apex rounded, termen obliquely rounded; pale ochreous; a faintly darker discal dot at two-thirds; cilia pale ochreous. Hindwings with 5 from or from below middle; pale grey; cilia pale grey.

Very similar to *E. phoenissa*, which occurs in the same locality, but smaller, forewings narrower, apex more pointed, antennal ciliations shorter (in *phoenissa* nearly 2).

Queensland: Milmerran in September; eight specimens.

863. EULECHRIA OMOSEMA Meyr., *Exot. Micro.*, ii, 372 (Dorrigo, Ebor).

864. EULECHRIA PACIFERA Meyr., ibid., i, 165 (Darwin, Townsville).

865. EULECHRIA HOMOCHRA, n. sp. (ὁμωχρος, uniformly pale.)

♂. 20–22 mm. Head and thorax ochreous-whitish. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; pale fuscous, extreme apex of second joint whitish. Antennae grey-whitish; ciliations in male 2½. Abdomen grey-whitish. Legs ochreous-whitish. Forewings slightly dilated, costa moderately arched, apex rounded, termen obliquely rounded; ochreous-whitish with minute fuscous dots; first discal at one-third, plical slightly beyond, second discal before two-thirds; a submarginal line of very minute dots from two-thirds costa to tornus, strongly curved; cilia ochreous whitish. Hindwings and cilia whitish.

Distinguished from *E. corsota* by the longer antennal ciliations, the submarginal line of forewings (but the latter is not always developed) and whitish hindwings.

New South Wales: Ebor in February; two specimens.

866.† Eulechria epixesta Meyr., P.L.S.N.S.W., 1888, 1582 (York, W.A.).

867.† Eulechria puellaris Meyr., ibid., 1882, 522 (Duaringa).

868. Eulechria achalinella Meyr., ibid., 1882, 523 (Atherton, Duaringa to Melbourne. Tasmania. Mt. Lofty. Albany, Denmark, Perth, W.A.).

869. Eulechria centridias Meyr., *Exot. Micro.*, ii, 373 (Mt. Lofty).

870. Eulechria pantelella Meyr., P.L.S.N.S.W., 1882, 520 (Macpherson Range to Mittagong).

871. Eulechria tephrochroa Turn., ibid., 1916, 362 (Rosewood, Q.).

872. Eulechria haplosticta, n. sp. (*ἁπλοστικτος*, simply spotted.)

♂. 22 mm. Head, thorax, and abdomen pale grey. Palpi with second joint much exceeding base of antennae, terminal joint three-fourths; grey. Antennae grey; ciliations in male 2½. Legs fuscous (posterior pair missing). Forewings somewhat dilated, costa slightly arched, apex rounded, termen obliquely rounded; pale grey with blackish dots; first discal at one-third, plical slightly beyond it, second discal before two-thirds; a subterminal series of dots; cilia pale grey. Hindwings and cilia whitish.

New South Wales: Mt. Kosciusko in December; one specimen received from Mr. G. M. Goldfinch, who has the type.

873. Eulechria amphidyas Meyr., P.L.S.N.S.W., 1887, 950 (Adelaide. York, Geraldton, W.A.).

874. Eulechria amolgaea, n. sp. (*ἀμολγαιος*, milky.)

♂. 20–22 mm. Head and thorax whitish. Palpi with second joint exceeding base of antennae, terminal joint three-fifths; whitish. Antennae grey; ciliations in male 1. Abdomen greyish-ochreous; apices of segments and tuft grey-whitish. Legs fuscous; posterior pair whitish. Forewings strongly dilated, costa moderately arched, apex pointed, termen nearly straight, moderately oblique; whitish; stigmata small, dark fuscous, first discal at one-third, plical slightly beyond it, second discal slightly beyond middle; sometimes a very slender interrupted fuscous subterminal line; cilia whitish. Hindwings with 5 from middle; whitish-grey; cilia grey-whitish.

Western Australia: Kalamunda, near Perth, in December; three specimens received from Mr. W. B. Barnard, who has the type.

875. Eulechria basipuncta, n. sp. (*basipunctus*, with basal dot.)

♀. 19 mm. Head and thorax pale grey. Palpi with second joint reaching base of antennae, terminal joint nearly 1; grey-whitish. Antennae and abdomen pale grey. Legs pale grey; posterior pair grey-whitish. Forewings narrow, suboval, costa slightly arched, apex rounded, termen obliquely rounded; grey-whitish with dark fuscous markings; a very fine subcostal streak near base; a subdorsal dot near base; stigmata small, first discal at one-third, plical beyond it, second discal before two-thirds; a series of dots close to margin from beneath two-thirds costa round apex and termen to tornus; cilia grey-whitish. Hindwings and cilia whitish-grey.

Near *E. tephrochroa* and *E. stigmatophora*. Best distinguished by the basal markings of forewings.

North Queensland: Cape York in October; one specimen received from Mr. W. B. Barnard.

876. Eulechria dysphorata, n. sp. (*δυσφωρατος*, hard to detect.)

♂, ♀. 19–20 mm. Head ochreous-whitish. Palpi with second joint reaching base of antennae, terminal joint three-fourths; fuscous, terminal joint and part of inner surface whitish. Antennae grey; ciliations in male one-half. Thorax

whitish-grey. Abdomen grey suffused with brown on dorsum. Legs grey; posterior pair ochreous-whitish. Forewings oval, costa strongly arched, apex rounded, termen very oblique; whitish-grey; markings fuscous; a costal streak to one-fourth, sometimes thickened to form a basal spot; stigmata minute, first discal at one-third, plical beneath it, second discal before two-thirds, a dot between and above discals, another above and beyond plical, some irroration on veins before termen; cilia whitish-grey. Hindwings and cilia pale grey.

New South Wales: Brunswick Hds. in December and January; three specimens received from Mr. W. B. Barnard, who has the type.

877. EULECHRIA CYCLODESMA, n. sp. (κυκλοδεσμος, with rounded chain.)

♂. 18–22 mm. Head, thorax, and abdomen grey. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; grey. Antennae grey; ciliations in male 3. Forewings narrow, slightly dilated, costa slightly arched, apex pointed, termen obliquely rounded; 2 and 3 connate; whitish-grey; stigmata small, blackish, first discal before one-third, plical slightly beyond it, second discal in middle; a rounded chain of minute blackish dots between veins from three-fourths costa to tornus; cilia pale grey. Hindwings and cilia pale grey.

Victoria: Beaconsfield in October; Macedon in November; three specimens. Type in Coll. Lyell; one example in National Museum, Melbourne.

878. EULECHRIA LEPTOBELA Meyr., P.L.S.N.S.W., 1882, 521 (Sydney, Katoomba).

879. EULECHRIA MAESTA, n. sp. (*maestus*, melancholy.)

♂, ♀. 16–18 mm. Head, thorax, and abdomen fuscous. Palpi with second joint reaching base of antennae, stout, terminal joint two-thirds; ochreous-whitish. Antennae grey; ciliations in male 1½. Legs fuscous; posterior pair ochreous-whitish. Forewings somewhat dilated, costa strongly arched, apex rounded, termen obliquely rounded; fuscous with darker markings; a spot on base of costa; stigmata obscure, first discal at one-third, plical slightly beyond, second discal before two-thirds; a curved subterminal line of dots; cilia fuscous. Hindwings and cilia grey.

Queensland: Macpherson Range (2,500 feet) in December; two specimens.

880. EULECHRIA THETICA Turn., P.L.S.N.S.W., 1916, 362 (= *pithanodes* Meyr., *Exot. Micro.*, ii, 309) (Toowoomba to Murwillumbah).

881. EULECHRIA TIMIDA Meyr., *Exot. Micro.*, i, 165 (Townsville, Westwood).

882.† EULECHRIA PAUROGRAMMA Meyr., P.L.S.N.S.W., 1882, 542 (Mt. Wellington, Deloraine).

883. EULECHRIA PUDICA Low., ibid., 1900, 41 (= *leucopis* Low., *Tr.R.S.S.Aust.*, 1902, 241) (Broken Hill).

884. EULECHRIA HAPLOPOLIA, n. sp. (ἁπλοπολιος, simply grey.)

♂, ♀. 22–24 mm. Head and thorax whitish-grey. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; whitish-grey. Antennae grey; ciliations in male 2. Abdomen brownish; apices of segments and tuft pale grey. Legs grey-whitish; posterior pair ochreous-whitish. Forewings suboblong, costa gently arched, apex rounded, termen obliquely rounded; stigmata small, blackish, first discal at one-third, plical slightly beyond it, second discal before two-thirds; a subterminal series of minute blackish dots, often partly or wholly obsolete; cilia whitish-grey. Hindwings and cilia pale grey.

Queensland: Rockhampton in October; Brisbane in November, December, and March; five specimens.

885. EULECHRIA LEPTOPASTA, n. sp. (λεπτοπαστος, finely sprinkled.)

♂. 18–19 mm. Head and thorax brownish-grey. Palpi with second joint exceeding base of antennae, terminal joint three-fourths; pale grey, terminal

joint grey-whitish. Antennae grey-whitish; ciliations in male 1½. Abdomen grey-whitish; bases of segments brown. Legs ochreous-whitish; anterior pair fuscous. Forewings dilated, costa slightly arched, apex rectangular, termen slightly oblique, rounded beneath; brownish-grey with fine uniform sparse fuscous irroration; markings fuscous; stigmata small, dark fuscous, first discal at one-fourth, plical slightly beyond it, second discal slightly beyond middle; a series of dots close to margin from beneath midcosta around apex and termen to tornus; cilia grey-whitish, with a median series of fuscous dots. Hindwings and cilia ochreous-whitish.

New South Wales: Moruya in October. South Australia: Mt. Lofty (Woodside) in December. Two specimens.

886. Eulechria eriphila Meyr., P.L.S.N.S.W., 1887, 946 (Macpherson Range to Hobart).

887.† Eulechria orbitalis Meyr., *Exot. Micro.*, ii, 511 (Cairns).

888. Eulechria ochrosarca, n. sp. (*ὠχροσαρκος*, pale flesh-coloured.)

♂. 22 mm. Head and thorax fuscous. Palpi with second joint reaching base of antennae, terminal joint four-fifths; fuscous. Antennae pale grey with fine fuscous annulations; ciliations in male 1½. Abdomen ochreous-whitish annulated with ochreous. Legs fuscous; posterior pair ochreous-whitish. Forewings suboblong, somewhat dilated, costa gently arched, apex rectangular, termen rounded, slightly oblique; pale ochreous-reddish; a blackish dot on dorsum near base; stigmata blackish, first discal at one-third, plical well beyond it, second discal slightly beyond middle; a slender curved line of fuscous dots from beneath two-thirds costa to tornus; cilia concolorous. Hindwings and cilia pale grey.

New South Wales: Narara, near Gosford, in October; two specimens received from Mr. G. M. Goldfinch, who has the type.

889. Eulechria stigmatophora Turn., *Tr.R.S.S.Aust.*, 1896, 11 (Herberton to Moe).

890. Eulechria convictella Wlk., xxix, 566; Meyr., P.L.S.N.S.W., 1882, 518 (Townsville to Hobart).

891. Eulechria ichneuta Meyr., ibid., 1887, 944 (Albany, Perth, Mt. Dale, Geraldton, W.A.).

Alphabetical list of the species of Eulechria (Nos. 531-891).

acedesta (751), aceraea (558), acervata (610), achalinella (868), aclita (801), acrocapna (731), acropenthes (824), adoxella (752), aerodes (611), alopecistis (572), amaura (754), amauropis (755), amolgaea (874), amphidyas (873), amphileuca (635), amphisema (698), amydrodes (688), anadesma (809), anomophanes (590), antygota (613), aphaura (808), archepeda (654), argolina (821), argotoxa (767), atmopis (742), atmospila (832), atrisignis (764), autographa (837), autophyla (700), autophylla (854), axierasta (542), baryptera (780), basicapna (672), basipuncta (875), basixantha (713), bathrogramma (719), bathrophaea (676), blosyrodes (584), botryospila (833), brachymita (693), brachystoma (681), brontomorpha (596), calamaea (601), callimeris (640), callisceptra (626), calotropha (557), candida (563), capnonota (782), capnopleura (663), carbasea (643), cataplasta (637), celata (747), centridias (869), centroleuca (710), centrotona (707), cephalanthes (581, 735), cephalochrysa (639), ceratochroa (813), chlorella (587), cholerodes (561), chorodoxa (702), chrysoloma (683), chrysomochla (553), cirrhocephala (662), cirrhopepla (569), cnecocrossa (860), cnecopasta (679), comorrhoa (733), concolor (575), convictella (890), corsota (859), cosmocrates (627), cosmosticha (556), cremnodes (823), crepera (765), cretacea (602), crypsipyrrha (775), cryptea (725), curvilinea (543), cyclodesma (877), cyclophragma (629), cycnodes (853), cyphocentra (749), dedecorata (664), delochorda (603), delospila (847), delotis (830), diagramma (838), diasticha (607), diploclethra (544), dochmotypa (729), droserodes (697), ductaria (701), dysaethria (831), dyscolleta (609), dysides (717), dysimera (819), dysphorata (876), ebenospora (770), egregia (641), elaeota (636), embologramma (720),

empheres (846), encratodes (606), ephalta (836), epibosca (562), epicausta (548), epichrista (598), epipercna (692), epiphragma (545), episema (805), epixesta (866), erebodes (762), eremotropha (728), eriphila (886), eualdes (774), euchlora (778), eurycneca (540), eurygramma (554), euzancla (723), exanimis (858), feniseca (740), fervescens (593), foedatella (653), frigescens (619), fulvitincta (750), glaphyrota (736), gonostropha (759), grammatica (788), griseola (818), gypsochroa (628), gypsochyta (789), gypsomicta (589), gypsota (743), habrophanes (591), haemopa (798), halmopeda (618), haplopepla (817), haplopolia (884), haplosticta (872), haplostola (579), helictis (828), heliocoma (571), heliodora (534), hemiphanes (634), heptasticta (682), hetaerica (658), hexasticta (673), hiemalis (787), holodascia (814), holopsara (616), homochalcha (615), homochra (865), homochroa (857), homophanes (576), homophyla (578), homospora (841), homoteles (574), homoxesta (614), hymenaea (535), hyperchlora (586), hypnotis (852), hypopolia (657), ichneuta (891), idopsepha (835), indecora (803), infestata (844), instructa (631), irenaea (560), ischnodes (642), ischnophanes (696), isotima (848), jugata (622), laxeuta (706), leptobela (878), leptochorda (612), leptochroma (621), leptoplasta (885), leucocrossa (791), leucodelta (721), leucopelta (594), leucophanes (559), leucostephana (677), liquida (812), lissophanes (849), machinosa (659), macrostola (769), maesta (879), malacoptera (537), mathematica (661), mediolinea (715), megalophanes (757), melanogramma (839), melanogypsa (730), melesella (807), melichyta (668), menodes (822), meraca (699), mesamydra (684), mesophragma (714), metabapta (532), metaleuca (739), metaxutha (766), micranepsia (802), mobilis (758), mochlastis (785), molybdea (772), monoda (566), monoides (856), monospila (539), monozona (533), mucida (776), myriospila (829), myrochrista (669), napaea (652), nebritis (568), nephelopa (827), nephelospila (773), nephobola (551), niphobola (756), niphogramma (570), nomistis (820), notera (737), ochlophila (718), ochrocneca (761), ochromochla (727), ochrophaea (804), ochrophara (741), ochrosarca (888), oenoessa (797), ombrodes (552), ombrophora (694), omopasta (564), omosema (863), orbitalis (887), orbitosa (845), orecta (708), ortholoma (597), oxyptila (599), pachychorda (671), pacifera (864), pallidella (565), pantelella (870), paraleuca (705), parocrana (649), pasteoptera (666), paurogramma (882), pedetis (760), pediaula (738), peisteria (555), pelina (793), pelodora (825), pentaspila (744), percna (783), perioeca (665), perixantha (580), perpetua (753), phaeina (541), phaeochorda (638), phaeodelta (680), phaeomochla (800), phaeopepla (810), phaeosceptra (625), philostaura (779), philotherma (712), phlaura (784), phoenissa (861), phoryntis (745), photinopis (806), physica (709), picimacula (716), pissograpta (771), placophaea (660), plagiosticha (630), platyrrhabda (546), plesiosperma (651), plesiosticta (724), plicilinea (746), plinthochroa (815), poecilella (592), polybalia (768), polymita (686), prepodes (648), psarophanes (600), psathyropa (726), publicana (826), pudica (883), puellaris (867), pulvifera (620), punicea (816), pycnoda (763), pycnographa (632), rhabdora (685), rhadinosticha (704), rhodobapta (799), rhymodes (851), ruinosa (604), salsicola (567), schalidora (547), sciaphila (711), scioessa (777), scioides (689), sciophanes (695), scitula (644), scythropa (583), semantica (588), semnostola (623), sericopa (585), siccella (786), similis (577), sordidella (703), spilophora (687), spilophracta (840), stadiota (842), stenoptila (691), stephanota (595), stereospila (732), sthenopis (656), stigmatophora (889), stramentaria (722), styracista (624), synaptospila (796), synchroa (573), syncolla (674), synnephes (678), tanyscia (748), tanysticha (608), tephrochroa (871), tephropolia (792), themerodes (790), thetica (880), theticophara (850), thiobaphes (670), thiocrossa (646), thrincotis (617), timida (881), torvella (794), tranquilla (650), transversella (647), triferella (549), trigonosema (655), tropica (550), tyrodes (855), umbrifera (781), variegata (633), vicina (675), virgata (834), xanthocephala (795), xanthocrossa (645), xanthophylla (536), xanthostephana (531), xipheres (582), xipholeuca (690), xuthocrana (667), xuthophylla (538), xuthoptila (862), xylopterella (605), zalodes (734), zophoptera (843), zoropa (811).

A PRELIMINARY INVESTIGATION OF THE NATURAL HISTORY OF THE TIGER FLATHEAD (*NEOPLATYCEPHALUS MACRODON*) ON THE SOUTH-EASTERN AUSTRALIAN COAST. II.

FEEDING HABITS; BREEDING HABITS.

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(Six Text-figures.)

[Read 27th April, 1938.]

In 1930 the author spent some time at sea investigating the natural history of the tiger flathead (*Neoplatycephalus macrodon*), the chief food fish of New South Wales, and in 1934 Part I of these preliminary investigations was published (These Proceedings, lix, 1934, 71). The present paper deals with feeding and reproduction. Maps accompanying Part I show the location of the principal trawling grounds along the S.E. Australian coast.

The Food and Feeding Habits of the Tiger Flathead.

An unexpected obstacle was encountered in the impossibility of obtaining a really large number of guts for examination. As soon as the flathead are taken from the net they are washed in sea-water and packed away in ice without being gutted. This has been more or less standard practice for many years, and has led to the remarkable situation (according to the trawler men) that any gutted flathead is looked upon with suspicion in the markets; the buyers suspect that the fish has been out of water for an extra long time and has been gutted as a safeguard against putrefaction.

The total number of stomachs examined was 657, these being taken over a series of thirteen cruises at monthly intervals, and each cruise of an average length of eight days. In view of this small number, it was considered advisable to make the investigation a more or less qualitative one, and the results obtained are set forth below.

The outstanding anatomical features of the tiger flathead are the dorso-ventrally compressed body with powerful fins, the exceedingly wide gape of the mouth with strong recurved "canine" teeth on the premaxillae, vomer and palatines, and the large stomach with thick muscular walls; all of these features have a close relationship to the feeding habits of the fish, but a rather surprising feature was the discovery that the flathead is more of a mid-water feeder than was previously suspected, and may at times even approach the surface.

Whilst the flathead must spend a considerable time on the bottom, there is much evidence to show that there is a periodical migration towards the surface which puts them beyond the range of the otter trawl, so that over a given time there may be marked fluctuation in the size of the hauls. The writer had often been told about this "take-off after dark", and in the course of numerous cruises was able to confirm the fact. It has apparently been a common experience from

the beginning of the industry, and a search through the early records reveals repeated mention by the skippers, of the sudden decline of catches with the approach of night, and their return to normal the following morning. The example given below is from the records of the trawler "*Brolga*", for September, 1922:

Haul No. 10, time shot, 9 a.m., catch, 8,000 lb.—No. 11, 2 p.m., 6,000 lb.—No. 12, 6.30 p.m., 1,900 lb.—No. 13, 11.30 p.m., 1,400 lb.—No. 14, 4.30 a.m., 7,500 lb.—No. 15, 9 a.m., 5,700 lb.

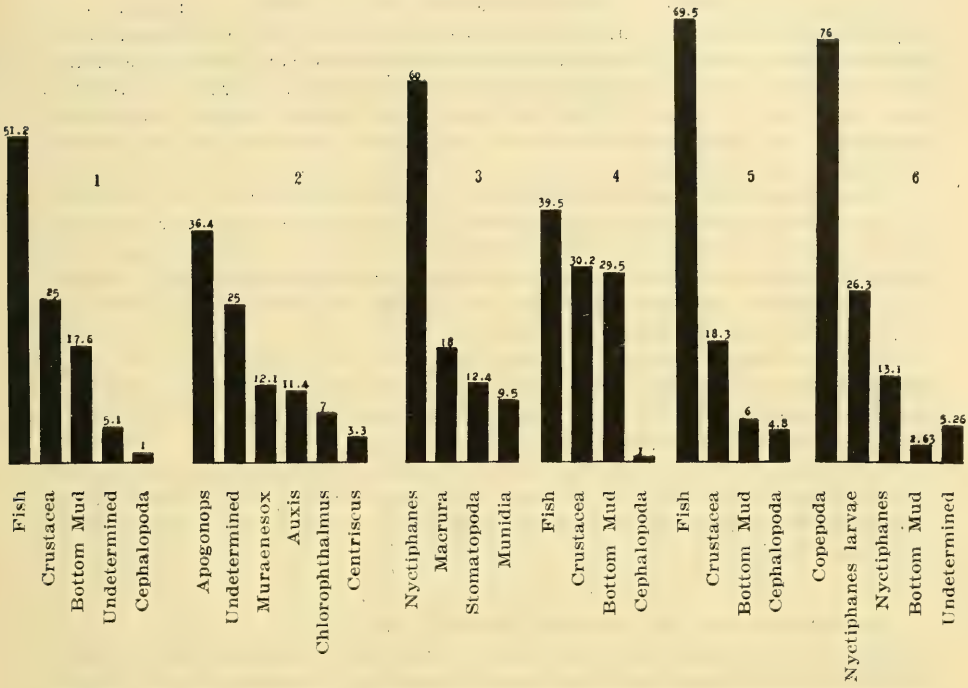
It became more or less a general thing for the boats to fish up till about 7 p.m., and then cease operations until the following morning, yet one must point out that heavy catches of flathead have been taken at night on occasions, which indicates that the fish do not always leave the bottom. There is a further possibility that the poor night fishing was due to a scattering of the shoals, an occurrence which is noticed with other species, but, as will be seen later, the food types eaten by the flathead favour the idea of a vertical migration. They prey extensively on the Euphausid *Nyctiphanes australis*, for instance, and the stomachs of even the largest individuals (i.e., up to 65 cm.) are frequently found distended with this small crustacean; furthermore, some of the remaining food types are mid-water or even surface forms.

In view of the small number of guts available, no attempt at an extensive separation into size classes was made, and a rough grouping was adopted, of "fish above 40 cm.", and "fish below 40 cm.". As the work proceeded, it became clear that a less arbitrary classification was afforded by "above 30–35 cm.", and "below 30–35 cm.", for at that size a considerable change of diet occurs, and also the female attains sexual maturity (at least, a 30 cm. female is the smallest mature fish we found).

Gut samples were taken on each cruise over a period of some fifteen months and, as they came from practically every fishing ground along the coast, may claim to give a fair qualitative representation of the food of the tiger flathead. It has not been considered necessary to publish the details of the contents of the separate guts, or even of the batches of samples from each cruise, and the results given below are a general analysis of the whole series.

Figure 1 gives the proportions of the food types for all sizes of flathead. The most common constituent is fish (51·2%), followed by crustaceans (25%). In 17·6% of the total number there was a varying quantity of "bottom mud", suggesting that the flathead may include bottom-living worms and other organisms which live with their bodies partially buried in the sand. The "mud" was found predominantly in the smaller sizes of fish. For the rest, 5·1% of the material was unidentifiable on account of advanced digestion, and 1% was represented by molluscs (small cephalopods).

Figure 2 shows the proportions of the different fish species found in the stomachs, whilst Figure 3 gives similar data for the crustaceans; in both Figures one particular species is seen to predominate over all the rest. The fish types consumed are not very numerous, and are apparently the most common acceptable members of the flathead's environment. They are as follows: *Apogonops anomalus* (called "Flathead Feed" by the fishermen), *Chlorophthalmus nigripinnis* (Cucumber Fish), *Auxis thazard* (Frigate Mackerel), *Muraenesox cinereus* (Silver Eel), *Trachichthodes affinis* (Nannygai), *Lepidotrigla mulhalli* (Mulhall's Gurnard or Cock Gurnard), *Macrorhamphosus elevatus* (Bellows Fish). The crustaceans are: *Nyctiphanes australis* (Euphausiacea—the so-called "Whale Feed"), *Munidia subrugosa* (Anomura), *Squilla laevis* (Stomatopoda), and an unidentified macruran shrimp.



Figs. 1-6.—Showing the proportions of (1) food-types consumed by the Tiger Flathead, (2) fish species in the food of the Tiger Flathead, (3) crustacean species in the food of the Tiger Flathead, (4) food-types for Tiger Flathead below 35 cm. in length, (5) food-types for Tiger Flathead above 35 cm. in length, and (6) food-types consumed by *Apogonops anomalus*.

Of the fish, *Apogonops* heads the list with 36·4%. It is quite a small fish, seldom exceeding five inches in length, and the specimens which came aboard in the otter trawl were generally 3–4 inches; they must have been very numerous at times, for, in spite of the exceedingly wide mesh of the net, many hundreds would be caught at a time. In addition to the other fish species shown in the figure, one specimen of the Nannygai (*Trachichthodes affinis*) and one of Mulhall's Gurnard (*Lepidotrigla mulhalli*) were taken.

The table for Crustacea (Fig. 3) shows that there is a marked predominance of *Nyctiphanes* (60%), as compared with the remaining species.

Figures 5 and 4 show respectively the food types for flathead above 40 cm., and below 40 cm. As already indicated, it was later discovered that a more significant grouping would have been "above 35 cm." and "below 35 cm.", and accordingly, the majority of individuals included in the first-mentioned exceeded 35 cm., whilst the individuals in the second group did not exceed a length of 35 cm.

In the latter group (Fig. 4) fish predominate (39·5%); next come Crustacea (30·2%), followed by "bottom mud" (29·5%). These results are in great contrast with those shown in Fig. 5, in which fish form 69·5% of the total, Crustacea only 18·3%, and "bottom mud" and cephalopods 6% and 4·8% respectively.

Nyctiphanes, as usual, is the commonest crustacean, and is preyed upon by the largest sizes of flathead. "Bottom mud" was found only in the stomachs of the smaller members of the group. These two figures show very clearly the change in diet which occurs as the flathead become larger, viz., a gradual forsaking of other food types in favour of fish; at least, in the present meagre state of our knowledge, that assumption appears to be justified, although it may require modification as work proceeds.

It would appear from these results that the larger flathead are less dependent on the bottom for their food supply, and tend to seek their prey elsewhere. The smaller flathead eat the same kinds of fish as the larger ones, but naturally the prey is of smaller average size, and not so many are swallowed at a time. Furthermore, the smaller flathead appeared to feed more frequently on the Silver Eel (*Muraenesox*) than did the larger ones.

The crustaceans, apart from *Nyctiphanes*, were generally of large size, more especially the stomatopods, which were up to four inches in length. *Nyctiphanes* apparently made up for its small size by its extreme abundance at the period of its maximum occurrence (early spring).

Unfortunately a very important link is missing in this work, in that the otter trawl did not capture any of the very small flathead, i.e., 1 cm.–15 cm., either because of the large mesh, or because these sizes are not normally found on the trawling grounds.

The Food of Apogonops.

Apogonops is the most important flathead food-type, and it is quite common for them to come up in the trawl, either because they were near the bottom, or because the trawl passed through a shoal of them as it was being hauled. A batch of 50 stomachs from the Newcastle Ground (see Text-fig. 2A, Proc. Linn. Soc. N.S.W., lix, 1934, p. 73) were examined and, with the exception of fourteen, contained varying amounts of planktonic material; of the fourteen, twelve were empty, and two contained "bottom mud", one of these containing also a small lygaeid hemipteran (Insecta). Of the 38 stomachs containing food, copepods were present in 29, *Nyctiphanes* larvae in 10, adult *Nyctiphanes* in 5, bottom mud in 2, and unrecognizable crustacean debris in 2. The relative proportions of the different food-types are shown in Figure 6, and it is seen that copepods come first (76%), followed by *Nyctiphanes* larvae (26·3%), *Nyctiphanes* (13·1%), with a still smaller percentage of "bottom mud", and unrecognizable debris.

In all, 374 copepods were counted; of these it was possible to identify 330, the balance being too far digested to permit of recognition. No less than 302 of the identified copepods were *Calanus brevicornis*, an interesting sidelight on the relative abundance of this form at the time. *C. brevicornis* is one of the larger copepods, attaining a length of 2·85 mm., and at times has been very plentiful in our plankton catches from the Sydney Heads Station, and from localities further north. The remaining 28 copepods were all medium to large in size, and ten of them were *Calanus minor*, another of our common copepod species. The following is a complete list of the species of Copepoda taken from the *Apogonops* stomachs: *Calanus brevicornis* (302), *C. minor* (10), *C. patagoniensis* (3), *C. tenuicornis* (2), *C. finmarchicus* (2), *Clausocalanus arcuicornis* (3), *Eucalanus attenuatus* (1), *E. elongatus* (1), *Rhincalanus nasutus* (1), *R. cornutus* (1), *Candace pectinata* (1), *C. bipinnata* (2), *Heterochaeta papilligera* (1). *Heterochaeta papilligera* had never been taken by us before, even in the plankton net.

The highest number of copepods identified from one stomach was 61, but the actual number would be slightly higher than this on account of the destruction of some individuals by digestion. A stomach from an 11 cm. *Apogonops*, fully distended by Euphausid debris, had a volume of approximately 1·2 c.c. (external measurements). This is the greatest volume so far noticed.

These results furnish interesting information with regard not only to *Apogonops*, but to the tiger flathead as well, although again not sufficient to justify a really definite statement. *Apogonops* has been shown to be a planktonic feeder in part, and this suggests that the flathead may pursue them into the upper layers of the water. If this is so, i.e., if the flathead are largely mid-water feeders, then the oft-repeated assertion that the present scarcity of flathead is due to destruction of the feeding grounds by the otter trawl, loses some of its force. In the early days of the industry the otter boards were shackled directly to the wings of the net, but the gear in its modern form has undergone considerable modification, in that fifty fathoms of very heavy steel warp are now interposed between net and boards. This means that a much greater extent of sea bottom is covered in a given time, and this factor is blamed for the much reduced hauls obtained during the past few years.

If this blame is justified, it is more probable that the bad effect is due to a general disturbance of the bottom rather than a destruction of feeding areas, and in any case a falling fishery is usually due to a very complex set of factors, no one of which alone could be entirely responsible for the reduction.

Other Factors Related to Feeding.

Food and Size Distribution.—The smaller sizes of flathead tended to occur in the shallow water near the coast, and hauls made in the deeper water provided individuals of a larger average size. This was particularly evident in the Eden area, where the grounds commence in thirty fathoms of water quite near the coast and extend out to sea for a considerable distance, the depth reaching 80 fathoms and more. Here, hauls made close inshore gave a predominance of small individuals, i.e., up to about 35 cm., whilst in the deeper water the average size was much greater. There is a marked difference in the bottom fauna in these two areas, for inshore there is an exceedingly abundant growth of large sponges, coelenterates, and polyzoans, and a very rich assemblage of molluscs, worms and crustaceans, thus presumably providing a very favourable feeding ground for the small flathead; on the other hand, the deeper waters appear to have a much less abundant bottom fauna, but if, as has been suggested, the larger flathead are only partially dependent on the bottom fauna for their food, then they would not be affected. Once again it must be stressed that this is an isolated case, and that many other factors must play their part.

The tiger flathead, small or large, is a voracious feeder, and at times engulfs enormous quantities of food. On one occasion the stomach of a 46 cm. flathead yielded a Silver Eel (*Muraenesox*) 42 cm. in length and approximately 2 cm. in cross section. The stomach walls were stretched to such an extent that they were quite translucent. At other times the stomachs have been tightly packed with either *Apogonops* or *Nyctiphanes*, and were many times their original size.

Parasites.—The tiger flathead is abundantly parasitized in the stomach region by a small nematode which not only hangs freely from the outer surface as masses of "ringlets", but is massed in the thickness of the walls as well. In the stomachs of the smaller fish were found numbers of a small trematode with a very short sub-cylindrical body and a prominent ventral sucker. One 25 cm. fish yielded no

less than thirty of these trematodes from between the folds of the mucous membrane. This restriction of the parasites to the smaller fish was very marked, the usual number found in each individual being 8–14, whilst it was rare to find more than one or two in flathead above 40 cm. In all positions in the body cavity were found specimens of a trematode with a yellowish cylindrical body up to 5 cm. in length. These parasites have not yet been identified as to systematic position.

Reproductive Organs and the Breeding Season.

This record is also essentially preliminary. The same ground was seldom visited twice in succession (monthly intervals), and it was not possible to secure a really large number of flathead each trip for dissection purposes. Dissection was necessary in all but mature individuals, in order to determine the sex, for the tiger flathead has no externally visible sexual dimorphism; in the case of ripe or nearly ripe fish there was usually some extrusion of reproductive products through the cloaca. It was in this work that one felt the need for a team of workers going out every trip throughout the year, instead of one individual at monthly intervals.

Breeding Season.

The first definite indication of this period occurs in September, although as early as July the ovaries show signs of development. In July, 1930, good hauls of large flathead were made on the New Zealand ground, and showed well developed ovaries. Although actually very immature from the viewpoint of breeding, these fish were spoken of by the fishermen as "full-roed"; indeed the writer found that few, if any, of them had actually ever seen a really ripe ovary with transparent ova, and they were surprised to learn that the roe could be very large without necessarily being "ripe". On this cruise similar flathead were taken in the Watta Mooli–Botany area.

Five weeks later, during August, 1930, the Pines–Tollgates ground was worked and the average size of the trawled fish was very small. A few large individuals were taken in each haul, and showed large but immature ovaries. Towards the close of this cruise the New Zealand ground was again visited, and the fish were found to be in a similar state of development to those taken on the previous cruise.

Cruise No. 7 took place in late September, and operations were concentrated on the strip of coastline extending from Bateman's Bay to Montagu Is., which thus corresponded largely with the ground worked on the previous cruise. As already mentioned, the average size had been very small on that occasion, but now the flathead were all on the large side, and showed well-developed ovaries. Some individuals, particularly those from the vicinity of Montagu Is., were very large indeed, 56 cm. specimens being quite common, and one 61 cm. female was taken; the ovaries of this fish were so large that they extended to the anterior limits of the body cavity, and caused considerable displacement of the other viscera. Another striking point about the hauls made in this area was the prevalence of large ripe or partially ripe males; in the past most of the males encountered had been very small and individuals of more than 50 cm. were rare. On this occasion, however, the size approached that of the females and the enormous testes occupied most of the body cavity.

The Watta Mooli–Botany ground was also worked at the close of this trip, and yielded flathead of very small average size; in fact, many of them were below the limits prescribed by the law, and had to be thrown overboard. On this ground a

30 cm. female with partially ripe ovaries was taken, and to date this is the smallest size known to us at which sexual maturity is reached.

Cruise No. 8, in November, 1930, was to the Newcastle–Port Stephens area, a ground which is regularly visited by the boats at this time of the year. The flathead taken on the Newcastle ground were remarkable for their large size, soft, easily damaged flesh, and poor keeping qualities as compared with the southern fish; there appears to be here a fruitful field for racial investigations, for even allowing for specialized physiological condition during the breeding season, it is a curious fact that the southern fish of equal size, and at a corresponding period, do not exhibit this remarkable softness and inferior keeping qualities.

On this Newcastle ground large males and females were taken, the biggest of the former just exceeding 54 cm., and of the latter the longest individual was 64 centimetres. These figures are the upper limits of size for the respective sexes so far encountered, and suggest the possibility of a size dimorphism in the two sexes. It has been our constant experience to find a predominance of females in the larger sizes, and the largest male taken was 10 cm. less than the largest female, in all the thousands of fish examined from many different areas; at the lower end of the scale, the smallest sexually-mature male was approximately 10 cm. shorter than the smallest sexually-mature female, the respective figures being 23 cm. and 30 cm. If the males and females do actually grow at different rates, then any scheme of age determination which is based on growth rates will be complicated considerably.

The gonads of these Newcastle flathead were very advanced in development; many ovaries were already showing a few transparent ova, and their general condition suggested that full maturity would be reached in a very short time. On this cruise three thousand fish were tested for ripeness, and of these only one small female proved to be fully so; it was, unfortunately, in such a damaged condition after leaving the net that it was useless for artificial insemination purposes. Spent females were also extremely rare, and no more than six were seen, the general impression being that whilst many of the flathead had commenced to shed their eggs, the majority still had to carry out that process.

The ninth cruise was on the southern grounds, Montagu Is., Watta Mooli, and the New Zealand ground being visited. At Montagu Is. the outstanding feature of the hauls was the large number of small fish taken, and of these the majority were males; in one batch of 75 small flathead dissected, no less than 50 were males, of an average length of 25 cm., most being sexually mature. Many very large females were also taken, and two of the number examined were quite ripe. At Watta Mooli the flathead were large but immature, whilst on the New Zealand ground small immature flathead were taken.

On the tenth cruise (Jan., 1931), the Eden–Green Cape area was again visited, and maturing flathead were very much in evidence. Many of the females had masses of transparent ova, although only one really mature individual was secured. As compared with the previous cruise to grounds a little further north, males were comparatively scarce, comprising only 21% of the total number of fish examined.

The eleventh cruise was to the same area, and the outstanding feature was the decrease in average size, large maturing individuals being relatively few in number. This was even more marked on the twelfth cruise, in April, 1931, to the New Zealand and Jervis Bay grounds, for large fish were not plentiful, and none had mature gonads. Some spent females were taken, and in the smaller size classes there was a decided preponderance of males (61%).

From the foregoing rather disjointed record it appears possible to draw the following general conclusions. The first definite signs of the breeding period occur in early spring, i.e., in September, when the gonads of the females begin to show marked increase in size. On the northern grounds, i.e., at Newcastle, in the month of October, there is an influx of very large flathead which would shed their ova towards the end of the month and perhaps in the early part of November. After this they disappeared, for the fishery had fallen off so much by early November that the boats returned to the southern grounds, where maturing females were very much in evidence, although very few really ripe females were seen. By March (early) there were definite signs of the cessation of the breeding season, and this was more marked in April. The breeding season for the tiger flathead may then be tentatively said to extend over a period of about four months, commencing (as far as oviposition is concerned) in October, and extending into perhaps the late part of February; apart from this, the northern fish seem to breed sooner than the southern ones and finish by about the middle of December.

One curious experience during these cruises was the great scarcity of really ripe females, for not more than a half-dozen were seen during the whole time the writer spent at sea; in this regard it may also be mentioned that spent females were almost as scarce. Many thousands of flathead passed through our hands in this period, not very many of them having even a few transparent ova in their gonads; thus we do not yet know where the flathead actually go for the final act of oviposition—whether they come close inshore where the trawlers cannot shoot their nets, or whether they rise to the surface. Furthermore, we do not yet know where they go immediately after oviposition, for, as indicated above, spent females were also very seldom seen in the large hauls that came up in the otter trawl.

There is, however, one well-established fact with regard to the movements of the tiger flathead at the time of breeding, and that is a migration from some place, at present unknown, into the waters embraced by the present fishing grounds; the shoals are largely made up of maturing females of large size, accompanied by mature males which are not quite so large as the females. It seems feasible that this migration is an east–west one, and appears to take place sooner on the northern grounds than on the southern.

The Number of Eggs Produced.

In this computation a portion of the mature ovary was weighed, the number of ova contained therein counted, and then, from the total weight of the ovary, it was possible to estimate the approximate number of eggs produced. The highest return from a number of ovaries was two and a half million. The testes of the largest males easily equalled the largest ovaries in size and must produce enormous numbers of sperm.

Experiments in Artificial Insemination.

Several attempts were made to obtain the very earliest developmental stages of the fertilized eggs, but all of these were unsuccessful; the outstanding difficulty was the acquisition of suitable material in the form of sexually-mature individuals, for, as already indicated, not more than a half-dozen really ripe females were seen, and all of these were dead when taken. Nevertheless, ova taken from them floated when placed in sea-water and, after insemination, appeared to be quite healthy; on the two occasions that experiments had reached this stage, violent gales were experienced, which not only upset the apparatus, but carried away a good deal of the trawler's equipment as well.

At the suggestion of Professor W. J. Dakin, celluloid "cages" were made to hold the fertilized eggs and to facilitate subsequent handling, e.g., removal of samples at intervals for preservation. These cages, the construction of which is described below, were allowed to float about in the large container of sea-water, and each one sheltered about two hundred eggs. It was found unnecessary to suspend the cage in order to keep it in an upright position, for it floated about half-submerged.

The construction of the cage is a very simple matter. The cylindrical body is 6 inches high and three inches in diameter, and is made from sheet celluloid about $\frac{1}{32}$" in thickness; it has a series of small windows, each one inch square, which are covered with coarse bolting silk. The bottom is a plain circle of celluloid cut to a tight push fit in the body, and also has a large silk-covered window cut in it. The top of the cylinder is closed by a square of bolting silk which is held in position by a band of celluloid which is slipped over the outside.

In making the cage a rectangular sheet of celluloid of suitable dimensions is marked out for the positions of the windows. These lines are deeply scored with a sharp-pointed instrument, and the small squares will break out easily if the celluloid is bent away from the score; it is useful to remember that this is the correct method for cutting celluloid, which does not respond nearly so readily to scissors. When all of the window spaces have been formed, the sheet is bent around to form a cylinder, with the edges overlapping a little, the latter being first smeared with a fairly strong solution of celluloid in amyl acetate and acetone (equal parts). The seam is then clamped between two pieces of wood until the celluloid solution has set. This does not take more than three or four hours, and the bottom can then be fastened in position by slipping it into the body and running a line of the celluloid cement around the junction of the two; this, too, will set very quickly into a thin, tough fillet of celluloid. Small squares of bolting silk are now stuck over the windows with the same type of cement, applied by means of a soft brush, and when these have dried the cage is immersed in changes of sea-water for several days in order to "season" it, and remove all traces of any harmful chemicals.

For the main sea-water container, a large galvanized bucket was used, holding about five gallons, and was provided with a tap at the bottom to facilitate the drawing off of used sea-water. This bucket, too, was submitted to prolonged soaking in changes of sea-water before using.

Summary.

Certain qualitative aspects of the food and feeding habits of the tiger flathead, as well as the question of reproduction, are discussed.

Food.—The feeding activities of the specimens examined are shown to be confined to a few forms, all of which occur abundantly in the flathead's environment. These food-types are principally either fish (5 species) or crustaceans (4 sp.), and in each case one species predominates; of the fish it is the small teleost *Apogonops anomalus*, and of the crustaceans the euphausid *Nyctiphanes australis*. Tables are given to show the relative proportions of the different food-types, and emphasize the fact that the tiger flathead is markedly a fish feeder. It is also shown that a change of feeding habits occurs as the flathead grow older, this being in the direction of an increased amount of fish in the diet, and it is suggested that this may be partly due to increased catching power. Closely connected with this is the fact that the larger sizes of flathead become less dependent on the bottom fauna for their food supply, and tend to become mid-water feeders, an interesting

discovery in view of the fact that there has been a tendency to regard the flathead as a typical bottom-frequenting form.

The food of the flathead's chief fish-food type (*Apogonops anomalus*) is also described, and shown to be almost entirely planktonic—large copepods, *Nyctiphanes*, crustacean larvae, etc., although *Apogonops* appears to feed occasionally on the bottom.

Reproduction.—The breeding season of the tiger flathead commences in the early spring and extends almost to the end of summer; this observation is based on periodical examination of the reproductive organs, but it is not yet possible to say where oviposition actually takes place because only about a half-dozen really ripe females were seen among thousands of fish examined, and spent females were also scarce. This presumably indicates that the flathead were not spawning on the actual fishing grounds.

Observations show that the northern flathead spawn sooner than the southern ones, the spawning period in the north terminating about the middle of December.

The tiger flathead produces up to two and a half million eggs in one season, although this number would be considerably smaller in the smaller flathead.

A description is given of the construction of a celluloid "cage" for holding fish eggs after artificial insemination, this being the type actually used by the writer.

In conclusion, the writer would like to stress the vital importance of continuing and amplifying this work; the present investigation merely skims the surface and gives a clearer idea of the problems facing future workers.

DESCRIPTIONS OF FOUR NEW SPECIES AND TWO VARIETIES OF EUCALYPTS.

By W. F. Blakely, Rev. E. N. McKie, B.A., and H. Steedman.

[Read 27th April, 1938.]

Eucalyptus erythrandra Blakely and Steedman, n. sp. "Rosebud Gum." *E. angulosa* Schauer, var. *robusta* Gardner, *Journ. Roy. Soc. W.A.*, xix, 1932-33, 88.

Frutex 4–6 pedes altus; folia alterna angusto- vel lato-lanceolata, petiolata, crassa, coriacea, 8–13 cm. longa, 2–5 cm. lata; umbellae 3–5-florae; pedunculi late ligulati, erecti vel recurvi, 15–20 mm. longi, 5–9 mm. vertice lati; gemmae sessiles, subcylindroideae, rostratae, rubrae, 25–30 mm. longae, 15 mm. latae; calyx obpyramidalis, quadrangulatus, cujus anguli interdum in alas angustas expansi; operculum conico-rostratum uni- vel bi-costatum, 10–15 mm. longum; filamenta creberrima, rosea vel rubra, microscopice glandularia; antherae oblongae, rimis longitudinaliter dehiscentes; fructus cylindrici vel campanulati, 4-angulati vel 4-alati, 25 mm. longi, 18–20 mm. lati; capsula alte adnata, 4–6-locularis; valvae ligneae interdum orificium latum aequantes.

A shrub 4 to 6 feet high; leaves alternate, narrow to broadly lanceolate, petiolate, thick, coriaceous, 8 to 13 cm. long, 2 to 5 cm. broad, venation distinct, the lateral veins numerous, diverging at an angle of 40° to 50° from the midrib, the intramarginal vein distant from the edge. Umbels axillary, 3–5-flowered; peduncles broadly ligulate, erect or recurved, 15–20 mm. long, 5–9 mm. broad at the top; buds sessile, subcylindroid, rostrate, pink or red, 25–30 mm. long, 15 mm. broad; calyx obpyramidal, 4-angled, the angles sometimes expanded into narrow wings, minutely rugulose between the wings, the calycine rim exceeding the broad staminal ring; operculum conical-rostrate, with one or two ribs, and faintly rugulose, thin, 10–15 mm. long, the short beak subcompressed; staminal ring broad; filaments very numerous, pink or red, minutely glandular; anthers oblong, opening in longitudinal slits. Fruit cylindrical to campanulate, sometimes unequally 4-angled or 4-winged, the tips of the wings terminating in four small teeth on the calycine rim, 25 mm. long, 18–20 mm. broad, the disc forming a rather broad annulus inside the thin calycine ring and partly extending over the 4–6-celled deeply adnate capsule, the tips of the strong valves sometimes flush with the somewhat wide orifice.

W. Aust.—Kundip, near Ravensthorpe, in damp sandy soil (H. Steedman, October, 1930). Its position is near *E. tetraptera*, from which it differs in the leaves, multiflowered umbels, and in the differently shaped buds and fruits. The glandular filaments and anthers, however, are somewhat similar to those of its ally. Both species grow in the same neighbourhood, but *E. tetraptera* favours rocky situations, while *E. erythrandra* grows in wet or damp sandy soil. It is a very ornamental species with attractive rose-coloured buds and red flowers, the latter being at their best about October and November, and are excellent for

cutting. It should be of special interest to apiarists, as it is of small size, with moderately large flowers containing numerous fertile stamens, a very deep nectary, and yields pollen and nectar in abundance.

E. GONIOCALYX F.v.M., var. PARVIFLORA Blakely and McKie, n. var. "Small-fruited Mountain Gum."

Ab *E. goniocalyce* typica gemmis minoribus, fructibus minoribus, campanulatis, valvis plus minusve exsertis separanda.

A tree 40–80 feet high (about 12–24 m.), with rough bark for a few feet at butt, smooth, close dirty-white above. Mature leaves falcate-lanceolate, acuminate, 12–23 × 1·5–2 cm. Umbels 3–7-flowered; buds shortly pedicellate, cylindroid, acute, 7 × 3 mm., the conical operculum as long as the campanulate calyx. Fruit campanulate, shortly pedicellate, 4–6 × 5–6 mm., disc small, forming a thickened annulus above the calycine ring, valves usually three, when mature exsert and spreading, leaving a wide orifice.

N.S.W.—"About two miles from Hanging Rock, four miles from Nundle; steep mountain side; some trees 70–80 feet high, perhaps more. Sedimentary rock formation" (Rev. E. N. McKie, B83, 28/10/1930). "Tree 40–50 feet high, gum-barked, butt rough-barked. Clinging to side of gorge", Wollomombi Falls (Rev. E. N. McKie, B382, 2/1935).

It differs from the typical form in the smaller buds and smaller campanulate fruits, with more or less exsert valves. It resists a fair amount of cold and should be useful for mountain forestry in fairly cold regions. Flowers September–November.

E. PAUCIFLORA Sieb., var. DENSIFLORA Blakely and McKie, n. var. "Multiflowered Cabbage Gum."

Haec varietas notabilis ab *E. pauciflora*, foliis tenuibus, umbellis multifloris, gemmis minoribus diversiformibus, fructibus minoribus et tenuioribus distinguenda.

Leaves lanceolate, thinly coriaceous, up to 11 cm. long, 1·5–3 cm. broad. Umbels 12–30-flowered; peduncles slender, 5–10 mm. long; buds pedicellate, pyriform, apiculate, 5 × 4 mm., the operculum hemispherical, apiculate or pileiform, shorter than the obconic calyx; pedicels slender, 2–3 mm. long. Fruit shortly pedicellate, pyriform, truncate, somewhat thin, 4-celled, valves enclosed, 9 × 8 mm.

N.S.W.—T. F. Grills' paddock, 17 miles east of Guyra (Rev. E. N. McKie, 23/12/34). A very marked variety differing from the common form in the thin leaves, multiflowered umbels, smaller and differently shaped buds, and in the smaller and thinner fruits. A useful variety for beekeepers in cold districts. Flowers January–February.

EUCALYPTUS CHRYSANTHA Blakely and Steedman, n. sp. "Golden Mallee."

E. sepulcralis F.v.M. var. *robusta* Gardner, *Journ. Royal Soc. W.A.*, xix, 1932–33, 88.

Frutex Mallee erectus, 8–10 pedes (2·4–3 m.) altus, ramis rigidis, angularibus; folia alterna, oblonga, lanceolata vel falcato-lanceolata, erecta, atroviridia, 5–6 cm. longa, 1–2 cm. lata; umbellae axillares, 3–6-florae; pedunculi elongati, ancipites, erecti, rigidi, 2·5–4·5 cm. longi, 4–5 mm. lati; gemmae subcylindroideae, insigniter pedicellatae, rugosae, 17 mm. longae, 10–12 mm. diametro; calycis tubus infundibuliformis, operculum acute conicum, crassum, 9–10 mm. longum; filamenta creberrima, flava; antherae angustae, cordatae, versatiles, rimis longis oblique aperientes; fructus ovoidei vel cylindroideo-urceolati, truncati, crassi, lignei, 22–27 mm. longi, 15–20 mm. diametro; discus circum orificium latum angusto annulo praeditus, capsula quadrilocularis alte inclusa.

An erect Mallee, 8 to 10 feet in height, with rigid angular branches. Leaves alternate, oblong, lanceolate to falcate-lanceolate, erect, firm and rigid, abruptly acute to shortly acuminate, tapering at the base into compressed petioles 15 to 20 mm. long, dark green on both surfaces, 5–10 cm. long, 1–2 cm. broad, venation visible, the lateral veins slightly irregular, diverging at an angle of 40–50° from the conspicuous midrib, the intramarginal vein somewhat distant from the thick nerve-like, subrevolute margin. Umbels axillary, 3–6-flowered; peduncles elongated, ancipitous, erect or spreading, rigid, 2·5–4·5 cm. long, 4–5 mm. wide. Buds tip-cat shaped, minutely rugose, 17 mm. long, 10–12 mm. in diameter; calyx-tube funnel-shaped, gradually tapering into the long angular pedicels, the operculum acutely conical, moderately thick and firm, 9–10 mm. long; filaments very numerous, white to light yellow; anthers narrow, cordate, versatile, opening obliquely in long slits, with a large terminal dorsal gland. Fruit ovoid to cylindroid-urceolate, truncate, thick and woody, slightly constricted at the orifice, 22–27 mm. long, 15–20 mm. in diameter, the disc forming a sharp narrow annulus around the broad orifice and increasing in thickness and obliquity internally, and partly concealing the deeply enclosed 4-celled capsule.

W. Aust.—Mount Bland, Eyre Range (H. Steedman, November, 1930 and 1932), the type. It is allied to *E. sepulcralis* F.v.M., from which it differs in the Mallee habit, broader and more coarsely veined green leaves, non-glaucous buds, and fruits, erect or spreading rigid umbels, ancipitous rigid peduncles, larger and differently shaped buds, robust pedicels, longer and thicker calyx-tube and operculum, and differently shaped fruits with a broad orifice. In fact it differs from its ally in every character except the filaments and anthers. It is a very handsome dwarf species; the yellow filaments are a pleasing contrast against the dark green foliage. It is recommended for horticultural purposes in temperate and subtropical localities. It blooms about November and the large flowers are heavily laden with nectar and pollen.

EUCALYPTUS MICHAELIANA Blakely, n. sp. "Brittle Gum."

Arbor mediocris, cortice levi, deciduo, ligno rufo; folia matura, alterna, petiolata, lanceolata vel falcato-lanceolata, acuminata, dilute viridia, 10–18 cm. longa, 2–3·5 cm. lata; foliorum venatio subtilissima, subobscura, venae laterales haud numerosae, distantes, incompositae, a costa media prominente angulo 40–45 graduum divergentes, vena intramarginalis a margine crasso remota. Inflorescentia terminalis, breviter paniculata, umbellis 3–6-floris; gemmae brevipedicellatae, conicae, adhuc statu maturo non visae; fructus cupulares vel campanulati, glabri, breviter pedicellati, 3–4 mm. longi, 4–5 mm. lati, quisque cum disco parvo annulari et 3–4 valvis minutis inclusis.

Tree of average size, irregular trunk, with a smooth deciduous bark somewhat similar to the bark of *E. maculata*. Timber red and brittle (Campbell). Mature leaves alternate, petiolate, lanceolate to falcate-lanceolate, acuminate, pale green on both surfaces, drying a pale grey colour, 10–18 cm. long, 2–3·5 cm. broad, the venation very fine, not prominent, except the midrib, which is conspicuous on both surfaces, but more prominent on the lower, the lateral veins not numerous, rather distant and irregular, diverging at an angle of 40–45° from the midrib, the secondary veins openly reticulate; intramarginal vein undulate, remote from the thickened nerve-like margin; petioles compressed and sometimes twisted, 1·5–2 cm. long. Inflorescence at first terminal, infraterminal in fruit, shortly paniculate to corymbose, the main axis very short and stout. Umbels 3–6-flowered, the peduncles compressed, angular, 5 mm. long; buds shortly pedicellate, conical, but not seen

in a mature state; anthers not seen. Fruit cupular to campanulate, smooth, shortly pedicellate, 3–4 × 4–5 mm., with a small firm annular disc slightly exceeding the calycine ring, and 3–4 very small enclosed valves; seeds brown, minutely fimbriate and slightly costate, less than 2 mm. long and broad.

N.S.W.—At Hillgrove and Enmore (J. F. Campbell, March, 1907), the type. "Tree with smooth bark from the ground. The general appearance of the crown of the tree is similar to Spotted Gum. Height to 40 feet, and 2 feet in diameter, b.h.; tree of poor form, occurrence not common. Elevation about 4,000 feet; formation shale, Enmore State Forest No. 330, 26 miles from Armidale" (F. M. Bailey, No. 22, 11/4/1935). Q'land: "A tall, clean-limbed Eucalypt, height up to 70–80 feet. In the distance the trunk resembles *E. propinqua* or *E. major*, with a little roughish bark a few feet from base, and then smooth and pearly grey; timber reddish. Mount Ballow" (Rev. N. Michael. No. 2662. 19/7/1937).

The subpaniculate inflorescence and shape of the fruit and seeds, together with the venation, point to it being a Macrantherous species, and it is placed tentatively in Series Paniculatae next to *E. intertexta* on the above evidence. Named in honour of the Rev. Canon N. Michael, Church of England Minister, Boonah, who has taken a life-long interest in the flora of Queensland.

EUCALYPTUS RHODANTHA Blakely and Steedman, n. sp. "Rose Gum."

Frutex valde glaucus, 2–2·5 m. (6–8 pedes) altus, ramulis divergentibus. Folia matura opposita, sessilia vel amplexicaulia, orbicularia, interdum acute cordata, coriacea, 5–10 cm. longa, 4–9 cm. lata. Flores singulares, ad pedunculos graciles, 1–3 cm. longos, deflexos affixi; gemmae pedicellatae, ovoideo-turbinatae, rostratae; operculum late conicum, acuminato-rostratum, costellatum, 10–15 mm. longum, 15–18 mm. basi latum; filamenta rubra; antherae versatiles, obovatae vel sub-panduriformes, poris latis lateralibus aperientes. Fructus pedicellati, lignei, turbinati vel sub-campanulati, bicostati nec non irregulariter costellati, 15 × 20 mm.; discus unicus aliquantum semiconicus ad basin valvarum lignearum exsertarum circumfusus.

A very glaucous shrub 6–8 feet high, branching from the ground and spreading out to 10 feet at centre; stem at ground-level 6–8 inches diameter, the main branches 2–4 inches diameter; bark smooth and glaucous. Mature leaves opposite, sessile to amplexicaul, orbicular to very acutely cordate, sometimes tapering into long acuminate points, glaucous on both surfaces, moderately thick, coriaceous, 5–10 cm. long, 4–9 cm. broad, the venation moderately distinct, lateral veins very thin, irregular and numerous, diverging at an angle of 50–65° from the prominent midrib, the intramarginal vein very fine and undulate, 2–4 mm. from the edge. Flowers solitary, on slender slightly deflexed, bicostate peduncles, 2–3 cm. long; buds pedicellate, ovoid-turbinate, rostrate, including the compressed pedicels, 4–5 × 2–2·5 cm.; calyx-tube broadly turbinate, bicostate or sub-dipterous, costellate between the wings, the operculum broadly conical and acuminate-rostrate, costellate, of a lesser diameter than the calyx-tube, 10–15 mm. long, 15–18 mm. broad at the base; filaments very numerous, in several rows, subcompressed, pink to dark rosy-red or crimson; anthers yellow, versatile, obovate to subpanduriform, opening in broad lateral pores, the connective with a very small semi-terminal dorsal gland. Fruit pedicellate, ligneous, broadly turbinate to subcampanulate, bicostate and irregularly costellate, 15 × 20 mm. or larger, the prominent ribs of the pedicel passing into the calycine portion and forming more or less conspicuous wings; disc single, somewhat semi-conical, fused to the base of the ligneous exserted valves, and paler than the thin calycine ring. Fertile seeds dark brown to black,

shell-like, nearly orbicular, with 3–4 radiating ribs extending into the wing-like expansion, 5 × 5 mm.; sterile seeds linear, angular, reddish-brown, 5–7 mm. long.

W. Aust.—"Victoria Plains, near Gunyidi, in a gravelly sand ridge with a friable subsoil" (H. Steedman, December, 1934). It is somewhat similar to *E. macrocarpa* Hook., in the colour of the foliage and flowers, but its habit of growth is quite different, being more bushy and compact, while the leaves are orbicular to cordate-acuminate, and not oblong-lanceolate like those of its ally. The long peduncles and winged pedicels, together with the costellate buds, acuminate-rostrate operculum, thinner calyx-tube, smaller and differently shaped fruits, also differentiate it from *E. macrocarpa*; the two are not associated in the field. It is of good form, and its frosted or silvery foliage and large rose-coloured flowers can hardly be surpassed for horticultural purposes, especially in temperate localities. It flowers almost every month of the year, but more prolifically from January to March, and yields both pollen and nectar freely.

MISCELLANEOUS NOTES ON AUSTRALIAN DIPTERA. IV.

GENUS ODONTOMYIA (STRATIOMYIIDAE).

By G. H. Hardy.

[Read 27th April, 1938.]

In this rearrangement of the species of *Odontomyia* certain characters are found to be significant, but in the past colour characters have usually been regarded as paramount for specific recognition. I have concluded that within the Commonwealth the genus is, in the main, a southern one.

I give below a key based on the colour characters upon which the various species have been described. I also add a key based on other characters for the identification of nine* species regarded as valid.

Key based chiefly on colour characters.

1. Face, frons and scutellum black 2
   Face and/or scutellum yellow, at least in part. Frons normally yellow just above the antennae 3
2. Legs yellow. (Cubital vein not forked—White.) ..... *opertanea* White
   Legs bicoloured ..... *marginella* Macq.; *annulipes* ♂ Macq.
3. Spines of scutellum turned upwards. Frons with spots. Scutellum entirely yellow. Legs bicoloured ..... *scutellata* Macq.
   Spines lying in the normal direction. Scutellum black basally, rarely otherwise .. 4
4. Face with at least the central area black. Legs bicoloured 5
   Face with the central area always yellow. Legs entirely yellow. Abdomen margined more or less widely with yellow but very variable in this respect 8
5. Abdomen without spots ..... *stricta* Erich.
   Abdomen with lateral spots 6
   Abdomen bordered with yellow ..... *annulipes* ♀ Macq.; *subdentata* Macq.
6. Abdomen spotted on second and third segments ..... *hunteri* Macleay; *sydneyensis* Schin.; *laterimaculata* Macq.
   Abdomen spotted on second to fifth segments 7
7. Spots small and well separated ..... *carinifacies* Macq.; *minima* Hardy
   Spots large and almost confluent ..... *grandimaculata* Hardy
8. Eyes of male with all small facets (Tasmania) ..... *picea* Walker
   Eyes of male with some very small facets below (which implies the upper ones are abnormally large and indicated only by Walker and Hill) 9
9. With narrow black abdominal stripe (character normal to males, rare on females) ..... *regisgeorgii* Guér.; *carinata* ♂ Macq.; *stylata* ♂ Macq.; *ialemus* Walker; *carinata* var. ♂ Walk.; *kirchneri* Jaen.; *pectoralis* Thoms.; *pallida* Hill.
   With broad black abdominal stripe (character normal to females and not frequent on males) ..... *carinata* ♀ Macq.; *stylata* ♀ Macq.; *rufifacies* Macq.; *amyris* Walker; *carinata* var. ♀ Walk.; *obscura* Hill.

Oxycera decipiens Guérin is omitted from the key on account of the uncertainty of its identity. It is suggested that the species might belong to the Hermetiinae. The species *decipiens* Hardy is definitely *regisgeorgii* Macq. 1838, and apparently

* There is a tenth species known, from Kosciusko (December, 1921—G. Waterhouse), which is not dealt with in these notes. It is rather like *grandimaculata*, but the abdominal spots are not confluent on the male and the scutellum is black in both sexes; in addition, the face differs from its Tasmanian ally.

Guérin's name should bear the same date, not 1830, which is the date of publication of the plate, but there is no figure of the species on it.

Key to valid species.

1. The eighth antennal segment short, shorter than the sixth. Face black, at least in part 2
   The eighth antennal segment long and strongly tapering, longer than the sixth. If short, face yellow 6
2. Scutellar spines very small and insignificant. Small branch of radial vein beyond stigma missing 3
   Scutellar spines strong and conspicuous. Small branch of radial vein beyond stigma present, or at least indicated. Legs normally bicoloured 4
3. Face, frons, and scutellum entirely black and the abdomen above almost entirely so, the green or yellow showing as a thin bordering line. Legs yellow .... *opertanea* White
   Face, frons and scutellum almost or entirely black, abdominal markings on one or more segments. Legs usually bicoloured ..... *marginella* Macq.
4. Spines sloping at an inclined plane to the scutellum, which is entirely yellow or practically so. Face and abdomen entirely black ..... *scutellata* Macq.
   Spines directed to lie in a plane with the scutellum 5
5. Scutellar spines strong and well separated. Face black, at least over the central area, and the scutellum black basally. Usually two well-defined lateral spots on the second and third abdominal segments, but there may be more .. *hunteri* Macleay
   Scutellar spines much smaller and closer together. Colour marks approach those of *hunteri*, but vary to face frons and scutellum entirely black .... *stricta* Erich.
6. Face invariably black in centre covering carina. Abdomen normally with small spots at sides on female and large confluent reddish ones on male .... *grandimaculata* Hardy
   Face invariably yellow in the centre and usually entirely yellow 7
7. Male with normal eye-facets, the head not inflated. The face very wide so that the eye margins lie at about right-angles to one another, that of the female similarly wide. Frequently with a black bar just below the antennae and bordering eyes, on both sexes ..... *picea* Walker
   Male with the upper facets much enlarged, the head thus becomes inflated. The face narrower on both sexes, and entirely yellow; that of the male with the eye margins lying at an acute angle to each other 8
8. Antennae with the eighth segment normal, longer than the sixth. Carina also normal, long. Female with the yellow of the frons separated from the black by a bicurved line, the curves being very pronounced ..... *regisgeorgii* Macq.
   Antennae with the eighth segment short, shorter than the sixth. Carina also short. Female with the yellow of the frons separated from the black by a straight line ..... *pallida* Hill

ODONTOMYIA OPERTANEA White.

PROC. LINN. SOC. N.S.W., xli, 1916, 93.—Hardy, *Proc. Roy. Soc. Tas.*, 1917, 62; 1920, 60.

Originally described from a unique Victorian female specimen, the species has been recognized also from Tasmania and from the Blue Mts., New South Wales. Those specimens reported to be in the Macleay Museum from Western Australia need confirmation. The male is unknown.

ODONTOMYIA MARGINELLA Macquart.

Dipt. Exot., suppl. 4, 1849, 52; White, PROC. LINN. SOC. N.S.W., xli, 1916, 93; Hardy, *Proc. Roy. Soc. Tas.*, 1920, 59; *nec* White 1914, 1916.—? *O. annulipes* Macquart, Dipt. Exot., suppl. 4, 1849, 52; male only.

I do not think *subdentata* Macq. can belong here, as none of the specimens before me show yellow on the frons.

The eyes on the female are vivid green with a red bar about level with the antennae; there is a blotch above and another, less conspicuous, below. The male is unknown to me.

Macquart recorded the species in error as from Tasmania; the type locality is probably Sydney, and I have it only from southern Queensland. One Brisbane specimen is normal (Sunnybank, Feb., 1930), the other is conspicuously marked with yellow on the lower part of the face, scutellum and the lateral border of the abdomen, and the legs are entirely yellow, but otherwise the specimen agrees and may be an abnormal variation. There are six from Tallwood (January, 1936), all taken together haunting a patch of *Bassia Birchii* on the reserve adjacent to the township, and these are quite normal, with the yellow restricted to the basal part of the abdomen in addition to the line as on *opertanea*.

ODONTOMYIA SCUTELLATA Macquart.

Dipt. Exot., suppl. 1, 1846, 52; White, *Proc. Roy. Soc. Tas.*, 1914, 59; White, PROC. LINN. SOC. N.S.W., 1916, 91; Hardy, *Proc. Roy. Soc. Tas.*, 1920, 54.

White states that the eyes are brilliantly blue when alive. The species is known from Tasmania, Victoria and New South Wales; in the latter States it appears to be mainly a mountain species.

ODONTOMYIA HUNTERI Macleay.

Stratiomys hunteri Macleay, in King's Narr. Survey Austr., ii, 1872, 467.—*Odontomyia hunteri* Hardy, *Proc. Roy. Soc. Tas.*, 1920, 61 (*nec* White).—*O. laterimaculata* Macquart, Dipt. Exot., suppl. 4, 1849, 49; White, *Proc. Roy. Soc. Tas.*, 1914, 58, males only; White, PROC. LINN. SOC. N.S.W., xli, 1916, 94, males only; Hardy, *Proc. Roy. Soc. Tas.*, 1920, 54.—*O. carinifacies* Macquart, Dipt. Exot., suppl. 4, 1849, 51; Hardy, *Proc. Roy. Soc. Tas.*, 1920, 55 (*nec* White).—*O. sydneyensis* Schiner, Novara Resa Dipt., 1868, 60 (*nec* Hardy).

The four names are probably all based on specimens from Sydney. The species is found in New South Wales, Victoria and Tasmania.

ODONTOMYIA STRICTA Erichson.

Arch. f. Naturg., viii, 1842, 272; Walker, List Dipt. B.M., v, suppl. 1, 1854, 55 (*Stratiomys*); White, PROC. LINN. SOC. N.S.W., xli, 1916, 90, 100; Hardy, *Proc. Roy. Soc. Tas.*, 1920, 62.—? *O. subdentata* Macquart, Dipt. Exot., suppl. 4, 1849, 49 (*nec* White).—*O. carinifacies* var. *minima* Hardy, *Proc. Roy. Soc. Tas.*, 1920, 55.—*O. laterimaculata* White, *Proc. Roy. Soc. Tas.*, 1914, 58 (females only); White, PROC. LINN. SOC. N.S.W., xli, 1916, 94 (females only).

The species is common in Western Tasmania, the type locality. The species does not conform well with the characters given for *subdentata*, as no specimens known to me have the lateral margins yellow, but the scutellar spines are sometimes reduced.

The distribution covers Tasmania and Victoria; in the latter State it is mainly a mountain species occurring on the high plateaus. There are variations in markings as well as in size.

ODONTOMYIA GRANDIMACULATA Hardy.

O. carinifacies White, *Proc. Roy. Soc. Tas.*, 1914, 57; White, PROC. LINN. SOC. N.S.W., xli, 1916, 94; Hardy, *Proc. Roy. Soc. Tas.*, 1920, 55 (*nec* Macquart).—*O. carinifacies* var. *grandimaculata* Hardy, *Proc. Roy. Soc. Tas.*, 1920, 56.

The species is only definitely known from Tasmania, where it breeds in the brackish tidal waters of the coastal swamps. The sexes differ in appearance, the male hitherto only being recognized with assurance, and the long series of females taken with them is now relegated to the type series.

ODONTOMYIA PICEA Walker.

? *O. annulipes* Macquart, Dipt. Exot., suppl. 4, 1849, 52, females only; White, PROC. LINN. SOC. N.S.W., xli, 1916, 90, 92.—*O. picea* Walker, Ins. Saund., Dipt., i, 1850, 78; List Dipt. B. Mus., v, suppl. 1, 1854, 55 (*Stratiomys*); White, PROC. LINN. SOC. N.S.W., xli, 1916, 90, 100.—*O. marginella* White, *Proc. Roy. Soc. Tas.*, 1914, 57; 1916, 260; White, PROC. LINN. SOC. N.S.W., xli, 1916, 93 (*nec* Macq.).—*O. subdentata* White, *Proc. Roy. Soc. Tas.*, 1916, 260; White, PROC. LINN. SOC. N.S.W., xli, 1916, 92; Hardy, *Proc. Roy. Soc. Tas.*, 1917, 62 (*nec* Macquart).—*O. amyris* Hardy, *Proc. Roy. Soc. Tas.*, 1917, 62 (*nec* Walker).

The description of Macquart's male *annulipes* does not agree with that of the female which might belong here as the band immediately below the antennae is mentioned; the type locality is likely to be Sydney, not Tasmania, as recorded. White's *marginella*, recognized on a specimen from Huon, probably belongs here and his *subdentata* certainly belongs. The species is only known to me from Tasmania.

ODONTOMYIA REGISGEORGII Macq.

Dipt. Exot., i, 1, 1838, 186; White, PROC. LINN. SOC. N.S.W., xli, 1916, 90, 100.—*O. carinata* Macquart, Dipt. Exot., suppl. 1, 1846, 52; White, *Proc. Roy. Soc. Tas.*, 1914, 59; 1916, 260; White, PROC. LINN. SOC. N.S.W., xli, 1916, 90.—*O. stylata* Macquart, Dipt. Exot., suppl. 2, 1847, 30; suppl. 4, 52; White, *Proc. Roy. Soc. Tasmania*, 1914, 56; White, PROC. LINN. SOC. N.S.W., xli, 1916, 90.—*O. ialemus* Walker, List Dipt. B. Mus., iii, 1849, 535; White, PROC. LINN. SOC. N.S.W., xli, 1916, 90.—*O. amyris* Walker, List Dipt. B. Mus., iii, 1849, 535; White, *Proc. Roy. Soc. Tas.*, 1914, 56; White, PROC. LINN. SOC. N.S.W., xli, 1916, 91 (*nec* Hardy, 1917).—*O. rufifacies* Macquart, Dipt. Exot., suppl. 4, 1849, 51; White, *Proc. Roy. Soc. Tas.*, 1914, 55, 56, 74; White, PROC. LINN. SOC. N.S.W., 1916, 90.—*O. carinata* var., Walker, List Dipt. B. Mus., v, suppl. 1, 1854, 312 (*Stratiomys*).—*O. kirchneri* Jaennicke, *Abh. Senck. Nat. Ges.*, vi, 1867, 323.—*O. pectoralis* Thomson, Eugenies Resa Dipt., 1869, 455.—*O. decipiens* Hardy, *Proc. Roy. Soc. Tas.*, 1920, 57 (? *nec* Guérin, 1838).

This synonymy is adapted from that published in 1920 under *decipiens* which may not belong to this genus.

The only Western Australian species, *regisgeorgii*, was described without a head. I have males before me from Perth. The Tasmanian *carinata* is too large to be confused with *picea*; the other names given by Macquart are probably based on specimens from Sydney.

Colour characters have been well covered by various descriptions, and there are specimens before me showing that the black on the female abdomen may be cut into symmetrical patterns by a reddish coloration that appears after death, as I have not noted this on any living specimen. The green and yellow are interchangeable, the eye-marks remaining the same in both, as also on females that have the pattern normal to the male. The eyes of the male are vivid green without marks, those of the female are vivid green with a red bar at about antennal level, and this does not reach the posterior border.

The species is known from all the States, and is abundant.

ODONTOMYIA PALLIDA Hill.

O. hunteri White, PROC. LINN. SOC. N.S.W., xli, 1916, 92 (*nec* Macleay).—*O. pallida* Hill, PROC. LINN. SOC. N.S.W., xliv, 1919, 456; Hardy, *Proc. Roy. Soc. Tas.*, 1920, 61.—*O. obscura* Hill, PROC. LINN. SOC. N.S.W., xliv, 1919, 457; Hardy,

Proc. Roy. Soc. Tas., 1920, 61.—*O. sydneyensis* Hardy, *Proc. Roy. Soc. Tas.*, 1920, 56 (*nec* Schiner).

The apical segment of antennae and the carina are shorter than those of *regisgeorgii*, and in this the species approaches *hunteri* Macleay. Hill described the two sexes as distinct species, but his figures agree with the present form which is the one upon which I based my identification of *sydneyensis*.

The species is rare in collections, and it is only recently that I have discovered the male and associated the sexes.

The eyes of the male are similar to those of *regisgeorgii*, but, when living, are vivid reddish with a purple bar lying along the upper margin of the small facets, the bar reaching both eye-margins. The eyes of the female are vivid green with a red bar at about antennal level, like that on *regisgeorgii*, but there is a blotch of red at the upper eye-margin, reaching the length of one-third of the frons. The markings of the male abdomen are typical of *regisgeorgii*, those of the female are not unlike those of *hunteri*. Other characters are given in the key.

Hab.—Northern Territory, Queensland and New South Wales. Rare in collections. Brisbane, 2 ♂, 2 ♀; Sydney, 1 ♀.

A NEW TERMITOPHILOUS PHORID (DIPTERA).

By Mary E. Fuller, B.Sc., and D. J. Lee, B.Sc., Council for Scientific and Industrial Research, Canberra.

(Twelve Text-figures.)

[Read 27th April, 1938.]

Only a few of the Australian Phoridae have been described, and of most of these the habits and early stages are unknown. The species described below was bred from larvae collected by H. J. Willings in mounds of *Eutermes exitiosus* in Sydney. The termitophilous habit is fairly common amongst Phoridae, and two of the Australian species are known to be associated with termites, namely, *Eutermiphora abdominalis* Lea in nests of *Eutermes fumipennis* (Lea, 1911), and *Dorniphora rhinotermitis* Schmitz and Mjöberg in nests of *Rhinotermes* sp. (Schmitz and Mjöberg, 1924). Our species runs in Schmitz's key (1929) to the genus *Diploneura*, which already contains two species (*D. conspicua* Borg. and *D. myersi* Brues, from Trinidad) bred from nests of *Eutermes* (Brues, 1932).

The writers are indebted to Mr. A. L. Tonnoir for advice on the systematics of the Phoridae, and to Dr. I. M. Mackerras for help in the preparation of the paper.

List of described Australian Phoridae.

Apiochaeta crassimana Brues, 1905 (N.S.W.), *A. debilis* Brues, 1905 (N.S.W.), *A. ? pulicaria* Fallen, 1823 (Australia), *A. sodalis* Brues, 1915 (N.S.W.), *A. tasmaniensis* Malloch, 1912 (Tasmania); *Dorniphora setitibia* Malloch, 1925 (Sydney), *D. nigrita* Malloch, 1925 (Sydney), *D. atratula* Malloch, 1925 (Sydney), *D. nigroscutellata* Malloch, 1925 (Sydney), *D. rhinotermitis* Schmitz & Mjöberg, 1924 (Atherton, Q.); *Phora nebulosa* Walker, 1857 (Tasmania); *Apocephalus niger* Malloch, 1935 (Sydney); *Sciadocera rufomaculata* White, 1916 (Tasmania); *Neopuliciphora microphthalma* Schmitz & Mjöberg, 1924 (Evelyne, Q.); *Eutermiphora abdominalis* Lea, 1911 (Sydney); *Diploneura scoparia* Brues, 1932 (Sydney and Brisbane), *D. gynaptera*, n. sp. (Sydney).

Diploneura gynaptera, n. sp.

A dark species about 3 mm. long, with yellow legs. Female apterous and puliciform. Male with a dark stigma on the wing.

♂. *Head* (Text-fig. 1): Frons broad, half the head-width, black and shining; ocelli present. Chaetotaxy complete, frontal bristles reclinate, in three straight transverse rows of four; anterior row arranged in two divergent pairs; supra-antennal pair erect and divergent. Frons with some small hairs between the bristles. One post-vertical bristle on each side; a row of strong postocular bristles continued to lower corner of eye, the last one larger than others; one oral bristle on each side, same length as last postocular; one genal bristle each side close to eye margin, smaller than oral bristles. Antennal cavities not well developed. Antenna orange-yellow; with basal segment cylindrical, but tapering slightly;

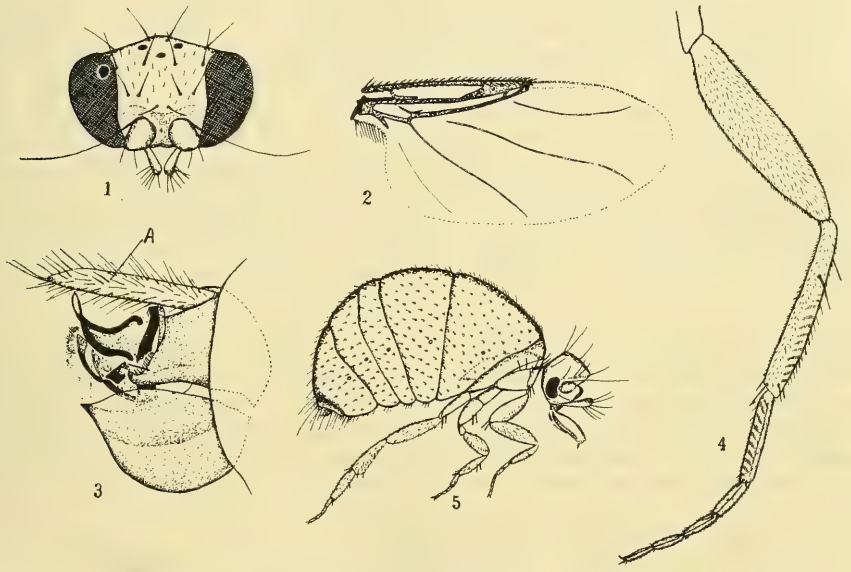
base of second segment visible, small and narrow; third segment somewhat dome-shaped and bulbous, finely but distinctly pubescent (basal joints apparently bare). Arista black, arising dorso-laterally and sub-apically from third segment, with first two joints short and bare, long thread-like third joint short pubescent. Eyes apparently bare, but at high magnification (× 100) seen to be clothed with exceedingly minute sparse, pale hairs. Palpi orange-yellow, finely pubescent; six strong black bristles near apex, and some smaller bristles at base. Proboscis short, labellae yellow, with pseudotracheae, and covered with fine hairs beneath.

Thorax: Mesonotum dark brown, almost black, covered with fine light brown hairs. Pronotum visible from above, as two small sclerites at sides of mesonotum, covered with similar hairs to mesonotum, bearing one strong humeral bristle. Mesonotum with one pair of dorso-central bristles at posterior border, and a straight line of five bristles along each lateral margin. Tegula with a fan of 7 or 8 bristles. Propleura with a pair of strong bristles near upper posterior edge directed upwards, and three bristles at the ventral margin directed downwards; a number of small hairs present. (Note: The chaetotaxy of propleura is variable, 3 upper in some and only 2 lower or a weaker third, but in holotype and most specimens as described.) Mesopleura undivided; without bristles or hairs; dark brown, with a greyish pruinescence when viewed obliquely. Halteres with a yellowish base and a dark brown knob with greyish pruinescence. Scutellum dark brown, almost black, shining, bare; more than twice as wide as long; four marginal bristles, inner larger than outer two. Wing hyaline, 3–4 mm. long (Text-fig. 2), covered with fine microtrichia; a single spine at base of radius; costa extending about half the length of anterior margin, costal bristles almost twice the width of vein; two stronger bristles at base of costa; second vein widened at end to a conspicuous brown stigma; third vein forked at end just before its junction with costa, the short cell so formed being wide. Squame small and rounded with close fringe of soft golden hairs; alular margin of wing with a fringe of long bristles.

Abdomen dark brown, with greyish pruinescence; hind margin of each segment with a narrow lighter band; a row of exceedingly minute hairs along hind margin of each segment, increasing in development from first to sixth, and a group at side margins. Sixth segment longer than others, with some minute hairs on dorsum as well as margin. Tergites normal, venter entirely membranous. Genitalia large, asymmetrical, yellow, with brown tinges below and at sides, where it has a greyish bloom like the abdomen; anal tube long, cylindrical and finger-like, yellow, clothed with long black hairs; outer or side pieces forming a cup enclosing the complex aedeagus (Text-fig. 3).

Legs yellow, robust, setulose, the hind pair longer than the others. Fore-legs with coxae greatly enlarged and dilated, almost five-sixths the length of femur, with three large bristles, two apical and one sub-apical; femur flattened, without bristles; tibia with some small single bristles slightly larger than the hairs, the strongest one dorso-central, two dorsal in apical half, and two at apex; faint postero-ventral transverse rows of fine golden cilia in apical half; tarsal segments with two black, longitudinal dorsal palisades. Mid-legs (Text-fig. 4) with coxae dark brown, yellow at apex, three large bristles externally, one being apical; femur without bristles; tibia with one dorsal and one antero-dorsal bristle in the basal fourth, and a crown of five at apex, with faint obliquely transverse antero-dorsal combs of golden cilia in the apical half, and one slightly-developed black dorsal palisade; tarsal segments with two palisades, one postero-ventral and one antero-ventral; metatarsus with well-developed oblique transverse combs of golden cilia

for whole length between the two palisades. Hind coxa with a narrow dorsal process, a pair of characteristic bristles before the apex, pointing outwards, and three at apex, one being larger than others; femur large; tibia with five apical spines, two dorsal palisades set close together, very faint development of combs of golden cilia at apex posteriorly; metatarsus with one antero-ventral bristle before the middle, and well developed oblique combs of golden cilia posteriorly; each tarsal segment with three palisades, the antero-dorsal and antero-ventral ones being strong and conspicuous, the dorsal one weaker; claws simple and equal; empodium bristle-like; pulvilli hairy.



Text-figs. 1-5.—*Diploneura gynaptera*.—1. Head of male, × 24 approx. 2. Wing of male, × 12. 3. Male genitalia, × 36; *a*, anal tube. 4. Mid-leg of male, × 22. 5. Female, × 15.

♀. (Text-fig. 5.) Length 2 mm. *Head* dark brown, smaller than that of male; frons very wide, about three-fourths of the head-width, shining, produced forwards above antennal cavity; eyes reduced; ocelli present. Chaetotaxy complete, and small hairs also present; bristles scarcely reclinate, more erect, supra-antennal pair perpendicular, rest of head-bristles as in male, but all more slender and hair-like. Palpi yellow, larger and more hairy than in male, the six bristles near apex more slender and longer. Proboscis much larger than in male, peculiarly developed into a strongly chitinized tube; labellae reduced, and a chitinous hook projecting between them ventrally. Antennal cavities more developed than in male, antennae the same colour but smaller, the third segment shorter and more rounded, arista with longer and more noticeable pubescence than in male.

Thorax very reduced, consisting of a very narrow dorsal strip which is hidden in a groove behind the head, has a row of fine hairs and a pair of small bristles and is probably the reduced mesonotum, as it widens laterally into a small triangular piece on each side, which is visible from above, and bears a series of five large bristles along the margin. The propleura is a small rounded oval

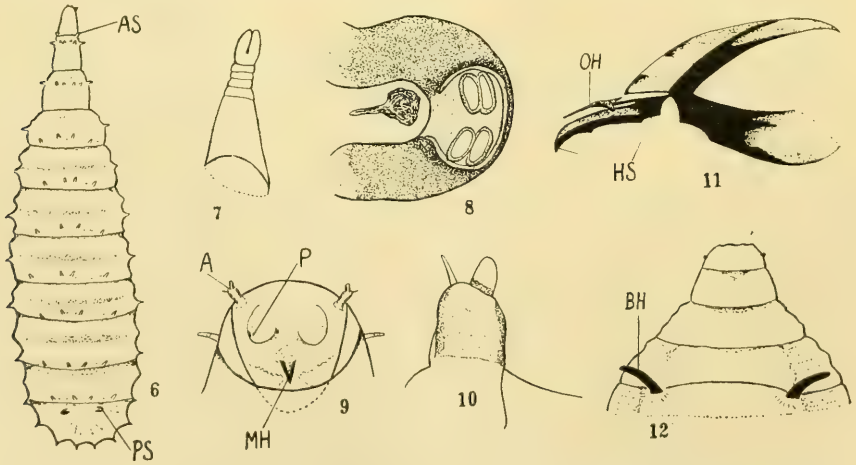
sclerite bearing a number of small bristly hairs, with two slightly larger ones above directed upwards and two below directed downwards; it has almost the same chaetotaxy as the male. The mesopleuron is bare. On clearing, some sclerites of the thorax, which are enveloped by the first abdominal segment, become visible internally. There are no vestiges of wings or halteres. Legs have the same structure as in the male but are reduced in size, with the tarsal segments, except the hind metatarsus, much shorter. There is no palisade on the fore-legs, a weak single palisade on the tarsi of the mid-legs, and a single anterior strong palisade on the tibia and tarsi of the hind-legs. The combs of golden cilia are well developed on the tibia and metatarsus of all legs.

Abdomen dark brown, shining and large, strongly convex above, all segments chitinous dorsally, becoming membranous laterally and ventrally. Five large segments, the first very elongate and produced dorsally above the legs with an anterior membranous fold reaching the back of the head; the sixth small and narrow and telescoped into the fifth. Ovipositor retracted, small, hairy, yellow. Whole of abdomen covered dorsally and ventrally with sparse, short, pale hairs arising from small dark pits; the anterior fold of first segment devoid of hairs; hind margins of fifth and sixth segments with long dense bristle-like hairs.

Distribution.—Sydney (February, 1935). Bred from larvae in mounds of *Eutermes exitiosus* (H. J. Willings). Holotype ♂, allotype ♀, and 8 ♂, 3 ♀ paratypes in the collection of the Division of Economic Entomology, Canberra.

The Larva.

The full-grown larva (Text-fig. 6) is 5·5 to 6·5 mm. long, club-shaped, and creamy-white in colour. The dorsal and ventral surfaces are convex, flattened into a slight ridge laterally. The head (Text-fig. 9) is bilobed, each lobe bearing a conspicuous antenna and a flat palp. The antenna (Text-fig. 10) consists of an elongate cylindrical segment, with a tiny dome-shaped segment at the apex, and a narrow pencil-like projection beside it. The palp is a flat disc with a small



Text-figs. 6-12.—*Diploneura gynaptera.*—6. Larva, × 9·5 (*as*, anterior spiracles; *ps*, posterior spiracles). 7. Larval papilla, × 360. 8. Posterior spiracle, × 290. 9. Head of larva, × 72 (*a*, antenna; *mh*, median hook; *p*, palp). 10. Antenna, × 360. 11. Mouth Parts, × 80 (*hs*, hypopharyngeal sclerites; *oh*, oral hooks). 12. Anterior end of puparium, × 20 (*bh*, breathing horn).

group of sensillae. The mouth-parts (Text-fig. 11) are small and of the same general structure as *Phora* (Keilin, 1911) and *Sciadocera* (Fuller, 1934). The pharyngeal sclerites have a wide gap or incision, with narrow cornua of equal length. The floor of the pharynx is ridged. The plate joining the dorsal edges of the pharyngeal sclerites projects forward over the hypopharyngeal sclerites, and consists of thin chitin with two arches of stronger chitin. The hypopharyngeal sclerite is narrow and elongate, joined at its posterior end to the pharyngeal sclerite. The arms are united ventrally, form a narrow trough dorsally, and are produced into a single strong down-curved hook at the anterior extremity. This curved point projects between the head lobes ventrally and is the only portion of the mouth part visible externally. The condition is unusual, the arms of the pharyngeal sclerite being normally connected only by the hypostomal arch and the point being small and supplementary to the buccal hooks. The oral hooks are reduced to a pair of very slender, lightly chitinized sclerites, lying above the hypopharyngeal sclerites and slightly lateral to them, and articulating with a short dorsal branch of these sclerites. They do not extend to the hooked end of the hypopharyngeal sclerites. They are bifurcated posteriorly and straight, narrow and pointed anteriorly. Projecting from the anterior edge of the pharyngeal sclerites are a pair of narrow rods of fairly light chitin, lying close to the dorsal side of the hypopharyngeal sclerites and extending to the base of the buccal hooks.

The thoracic segments are narrow and elongate, becoming progressively narrower from the third to the head, forming a "neck". Although the appearance of the larva is smooth, the whole of the surface, with the exception of part of the ventral area, is covered closely with minute, colourless spinules, as in the larva of *Dorniphora venusta* (Jones, 1918). Ventrally each thoracic segment bears a pair of tiny elevations, one on each side near the lateral edge, and each bearing two exceedingly fine hairs. Dorsally the first segment has a transverse series of four, and the second and third a similar series of six colourless, elongate papillae. These are ringed, giving them an apparent segmentation, and their apices are bifid (Text-fig. 7). The dorsum of each abdominal segment except the eighth bears a series of four papillae in the posterior third. There is a slight transverse groove in the centre of each segment extending across the dorsum. Laterally there is a protuberance bearing a papilla in line with the dorsal series. Anterior to this is a smaller, rounded lateral projection, and posterior to it a much smaller one. Thus each segment has three lateral projections, which gives a "scalloped" edge to the larva when viewed from above. The eighth segment is flattened and slopes away to the posterior extremity. It has six protuberances around the edge, each bearing a papilla. Ventro-laterally each segment bears a single large swelling with a papilla. There is a transverse groove across each segment ventrally, and the two fleshy ridges produced on each side of the groove are broken up into a series of rounded tubercles or pseudopods. There are six to each ridge, making twelve to each segment. The ventral surface of the eighth segment is reduced to a narrow strip bearing the anus in the centre, with a rounded swelling on each side of it, and a lateral protuberance bearing a small papilla. Occupying a postero-ventral position, posterior to the eighth is a small sternite, hidden from above and bearing a pair of large protuberances, probably the ninth segment.

The anterior spiracles are small, each consisting of a circular, brown plate at the end of a projecting tube containing the elongate felt-chamber. The plate has a thickened rim, and has three oval slits spread fan-wise. The posterior spiracles (Text-fig. 8) are near the anterior border of the eighth abdominal segment, are well separated, and are raised on a slight ridge. Each consists of a horseshoe-

shaped mass of chitin with the spiracular plate in the "toe", which faces laterally. There are two pairs of small slits in the plate, and the cicatrix or scar is in the opening or bay of the horseshoe.

As it proceeds towards pupation the larva becomes contracted, the neck becomes shorter, giving it a short bottle shape, and it becomes more flattened dorso-ventrally, and deeper cream in colour.

The Puparium.

The puparia producing male and female flies may be distinguished by the different shape and size. The male is 4½ to 5 mm. long and the female nearly 3 to 3½ mm. in length. The female is also broader in proportion to its length, and narrows more sharply to the anterior end. The general shape of the pupa is similar to the prepupa or contracted larva. It is flattened dorso-ventrally, although the dorsal and ventral surfaces are convex, the ventral being more strongly convex than the dorsal. It slopes away at each end. The chitin is strong and brown, a firm resistant shell being left when the fly emerges. The larval papillae remain as short projections or chitinous dots, being most distinct at the posterior end, and the spiracles are still noticeable.

The pupal breathing horns (Text-fig. 12) are elongate and strong, projecting upwards and sideways, being slightly curved. They are on the dorsum of the fifth segment. Dehiscence is across the sixth segment and along both lateral edges to the head-capsule, which consists of the first three segments, and splits off separately. The dorsal plate lifts off in one piece carrying the breathing horns. In *Sciadocera* and *Phora* the dorsal plate splits longitudinally down the centre.

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STUDIES ON THE PITUITARY BODY. I.

THE PHYLETIC OCCURRENCE OF PITUICYTES, WITH A DISCUSSION OF THE EVIDENCE FOR THEIR SECRETORY NATURE.

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(Plate v; five Text-figures.)

[Read 25th May, 1938—Manuscript received 2nd November, 1937.]

Bucy (1930, 1932), using Penfield's modification of del Rio-Hortega's silver carbonate technique (specific for oligodendroglia and microglia), demonstrated the presence of characteristic glial cells in the pars nervosa of the bovine pituitary gland. These he termed pituicytes. They are not numerous and are scattered throughout the nerve fibres and connective tissue which constitute the main mass of the gland. Ibáñez (1935) has described nerve fibres and embryonic glial cells in the partes nervosae of young dogs and cats. He distinguishes three types of nerve terminal. Previous to Bucy and Ibáñez, Berkeley (1894*a*, *b*) and Retzius (1894) succeeded in impregnating pituicytes. They used the inadequate and non-specific Golgi method. Cameron (1936) states that pituicytes constitute the bulk of the human pars nervosa, but gives no reference. I cannot find any description of the cytology of the human pars nervosa in the literature, published after the work of Bucy, except that of Trossarelli (1935). He used the Donnagio technique and described small cells and unmyelinated nerve fibres. Bucy considers that methods applicable to glial tissue other than silver carbonate impregnation are useless for showing the real cytological nature of the structure.

Recently it has been demonstrated by Geiling, de Lawder, and Tarr (1934) that it is the pars nervosa that elaborates pitressin (pressor, anti-diuretic principle) and pitocin (oxytocic principle), and not the pars intermedia as was thought by Herring (1908) and Cushing (1933). Herring (1908, 1913) stated that the pituitary of the skate (*Raja clavata*) exerts neither pressor nor anti-diuretic effects, but Hogben and de Beer (1925) have shown it to possess oxytocic properties. Hogben and de Beer also found no pressor activity in skate pituitaries, but quite marked pressor and oxytocic activity in Teleost pituitary extract. They deduce from the oxytocic properties of the two glands, that probably pitressin is not absent from Elasmobranchs but is present in small quantity. Pitressin and pitocin are formed in all classes of the Tetrapoda (Herring, 1913; Hogben and de Beer, 1925).

No research work has been carried out on the phyletic occurrence of pituicytes. This work was accordingly attempted with the view of supplying a comparative account of the cytology of the pars nervosa in the vertebrate series, and especially of providing a description of the conditions in Elasmobranchs, and to correlate, if possible, the presence or absence of pituicytes with the presence or absence of the hormones.

The anatomical nomenclature used in the various groups of Vertebrates is that given by de Beer (1926).

The writer wishes to take this opportunity to express his thanks to Professor W. J. Dakin for advice, and to Miss G. Burns for the preparation of the photographs.

Cytological Technique and Materials.

The technique used was Penfield's second modification of Hortega's silver carbonate method (quoted by Penfield and Cone in McClung, 1937). Instead of using the freezing microtome, sections were cut by the paraffin method.

The forms studied were.—Class Mammalia: *Sarcophilus harrisii* (Marsupial).—Aves: *Gallus domesticus* (Fowl).—Reptilia: *Tiliqua scincoides* (Skink lizard).—Amphibia: *Hyla aurea, H. coerulea* (Frogs).—Pisces: *Neoplatycephalus macrodon* (Teleost fish).—Elasmobranchii: *Raja australis* (Skate).

Cytological Observations.

Sarcophilus harrisii.—The pituicytes impregnate well with the silver carbonate. Large amounts of connective tissue, as seen in the infundibular process of the ox, are not evident. Many of the pituicytes possess a vascular process which ends on the connective tissue investment of a blood vessel, and indeed many of the cells are orientated so that the vascular processes are at right angles to the vessels (Plate v, fig. 1). At the periphery of the gland also the pituicytes take up a position at right angles to the connective tissue covering. In other parts they exhibit no particular orientation and are distributed indiscriminately throughout the collection of nerve fibres which make up the main mass of the pars nervosa. Blood vessels are fairly numerous, but the vascular processes of some of the more remotely situated cells are extraordinarily long (Text-fig. 1, cell 3).

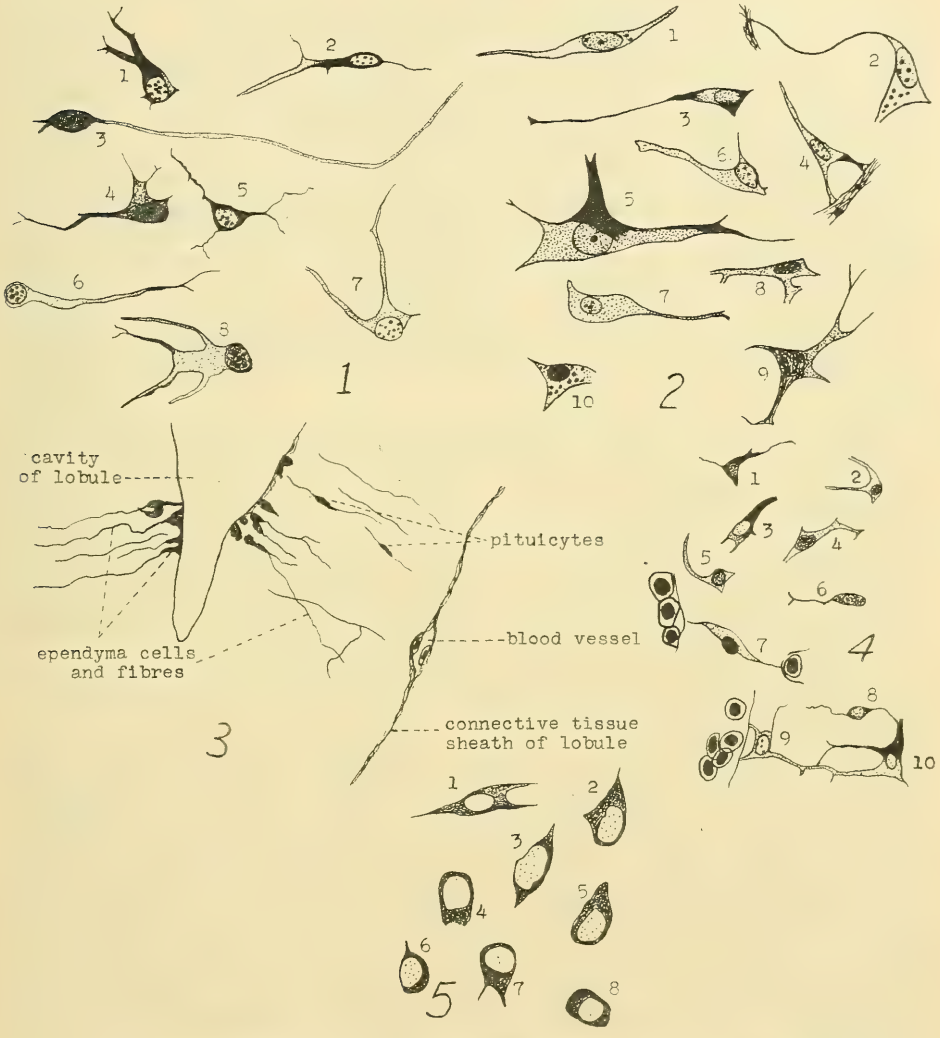
The cells vary greatly in shape (Text-fig. 1); some have several processes arising from the cell body; others, and by far the most frequent, are unipolar or bipolar. The cytoplasm in some cells is finely granular, in others appears a dense black, or both conditions may occur in one cell. Coarse cytoplasmic pigment granules, which occur in some of the bovine pars nervosa elements, were not observed in my preparations.

The nuclei, in general, are spherical or oval in shape. The chromatin is moderate in amount and diffusely distributed. Nucleoli were not seen. Some of the nuclei stain so intensely that they appear homogeneous and the chromatin granules cannot be made out.

Gallus domesticus.—During the course of development of the pituitary complex in the chicken, finger-like processes grow out of the distal portion of the infundibulum (de Beer, 1926). These persist in the adult, surrounded by a thin sheath of connective tissue, but much of their lobular character is disguised owing to the presence of masses of interstitial tissue, composed of nerve fibres, connective tissue, and blood vessels. Each lobular extension contains a portion of the infundibular cavity. The cavities of the extensions are all lined with ependyma. The ependyma cells can easily be identified in both haematoxylin-eosin, and Penfield preparations, being always arranged with their long axes at right angles to the border of the lumen. In silver carbonate preparations each cell has a long process which extends into the gland, away from the lumen. Connective tissue septa and blood vessels are plentiful. The pituicytes are distributed amongst the nerve fibres of the lobules and the interstitial masses, being most numerous in the latter. They are much smaller than those of *Sarcophilus*, as can be seen in Plate v, figs. 1 and 2.

Vascular processes are frequent, terminating on the connective tissue septa and on the blood vessels (Text-fig. 2, cells 2 and 4).

As usual, the pituicytes vary greatly in shape (Plate v, fig. 2, and Text-fig. 2). The cytoplasm is granular in some cases, stains intensely black in others.



Text-fig. 1.—*Sarcophilus harrisii.* Pituicytes, showing variety of forms assumed. Not to scale.

Text-fig. 2.—*Gallus domesticus.* Pituicytes, showing variation in form. Not to scale.

Text-fig. 3.—*Tiliqua scincoides.* Distal portion of lobule of pars nervosa. Showing two bipolar pituicytes among the ependyma processes. × 240.

Text-fig. 4.—*Neoplatycephalus macrodon.* Pituicytes, showing usual lack of uniformity in shape. Cells 8, 9, 10 reveal anastomosis and union of the cytoplasmic processes. Not to scale.

Text-fig. 5.—*Raja australis.* Pituicytes, showing fairly uniform shape, and absence of long cytoplasmic processes. Not to scale.

Occasionally coarse granules occur in the cytoplasm but do not resemble those found in bovine pituicytes, being much smaller and less numerous (Text-fig. 2, cells 2 and 10). Nuclei vary from a flattened oval shape to spherical. The chromatin is distributed as small granules. Nucleoli are seen occasionally.

Tiliqua scincoides.—The pars nervosa here consists of a few large lobular extensions of the infundibulum, each lobule containing a portion of the infundibular cavity, the cavities being lined with ependyma. The lobules are separated from one another by thin laminae of connective tissue. The actual nervous portion, which consists mainly of nerve fibres, is practically non-vascular. The blood vessels are restricted to the connective tissue sheaths. The processes of the ependyma cells stain well and are seen to extend from the lumen to the connective tissue at the periphery of the lobule. Some of the pituicytes (which occur scattered among the nerve fibres of the lobule) also have long processes which extend from the lumen, giving the impression that they are derived from the ependymal layer (Text-fig. 3). This is interesting in view of the fact that neuroglia is derived from ependyma during development (Penfield, 1932). The pituicytes are very small and not at all numerous. The nuclei are round and without distinct chromatin granules. In haematoxylin-eosin preparations the nuclei still appear homogeneous. The cell bodies possess the usual cytoplasmic processes (Plate v, fig. 3).

Hyla aurea and *H. coerulea.*—The results of preparations of the partes nervosae of these two types were uniformly poor. Numerous changes in times of mordanting, impregnation, and toning were tried with each batch of pituitaries, but without success. Very few of the cells impregnated, and these badly. The nuclei always impregnate well. Judging from these nuclei seen in silver preparations and those seen in haematoxylin and eosin preparations, the pituicytes are extremely numerous. Vascularity is marked. In the cells which impregnated, the cytoplasm appears to possess the usual processes extending out from the cell body (Plate v, fig. 4). A vascular process was observed in one instance.

Neoplatycephalus macrodon.—The pituitary of this form is of the usual Teleost type. The nervosa fits into the cup formed by the pars intermedia and in front penetrates into the "Übergangsteil".

The pituicytes are extremely small, numerous, and diffusely distributed throughout the whole extent of the pars nervosa. Blood supply is very plentiful. Vascular processes are present (Text-fig. 4, cells 7 and 9). The cells vary considerably in shape, but the processes for the most part are not long (Text-fig. 4). Teleost pituicytes appear to differ from all others in that occasional unions and anastomoses of the processes of two or even three cells occur. One such case is illustrated in Plate v, fig. 5, and Text-fig. 4, cells 8, 9, and 10. This is the most clear-cut example of such a structure, and here, at least, does not appear to be an artefact.

Raja australis.—The pars nervosa in this species is a quite well marked area extending out from the postero-ventral face of the infundibulum into the pars intermedia.

The pituicytes, treated with silver carbonate, present the typical staining properties of those in other classes, but are peculiar morphologically. They are variable in size, but mostly very large, fairly uniform in shape, possessing only one or two cytoplasmic processes (Text-fig. 5, and Plate v, fig. 6). Occasionally processes are absent. The nuclei in general are very large relative to the cytoplasm, and often are curiously indented. This occurs after formalin or Bouin fixation. Chromatin is scanty. Nucleoli are often present. The cytoplasm is very finely

granular and stains darkly. The pituicytes, owing to their lack of fine processes, stand out well in sections lightly stained with haemalum and eosin, the outlines of the cells agreeing well with those seen in silver preparations. Blood vessels are not numerous.

Discussion on the Secretory Nature of Pituicytes.

There are two characteristic elements of the pars nervosa which may reasonably be suspected of secreting pitocin and pitressin – nerve endings and pituicytes (Cowdry, 1934). Recent work (Parker, 1932, 1934; Feldberg and Gaddum, 1934; Feldberg, Minz, and Tsudzimura, 1934; Feldberg and Vartiainen, 1935) has produced evidence that nerve endings can elaborate hormonal agents. The answer to the question, whether they can secrete pitressin in the pars nervosa, has been supplied by the interesting work of Geiling and Lewis (1935), although these workers did not indicate the significance of this aspect of their work. They made tissue cultures of small pieces of mouse pars nervosa. The culture medium was changed every four days. At the end of fifty days the presence of pitressin was conclusively demonstrated. Now the cell-bodies of the nervosa nerve fibres are in the nucleus supraopticus (Clark, 1936). Consequently, if the gland is explanted, each nerve fibre and terminal is separated from its perikaryon, and Wallerian degeneration will occur. Therefore the hormone in the cultures could not have been formed by the nerve terminals. The cultures of neural lobe together with a little pars intermedia gave rise to "An abundant growth of long, flat, radiating cells, many macrophages, and extensive networks of large cells resembling neuroglia cells". The macrophages and flat radiating cells may be discounted as non-characteristic, probably derived from the pars intermedia, connective tissue and blood cells (radiating cells also occur in cultures of pars anterior and of pars intermedia), but those "resembling neuroglia cells" are undoubtedly the glial pituicytes. No nerve fibres were present in the culture, so that it may be said with a high degree of probability that the hormone was formed by the pituicytes. However, Geiling and Lewis did not test for pitocin, therefore it is possible that pitocin may be formed by the nerve terminals. Let us examine this possibility. Certain characteristics of the hormones formed by nerve terminals are not exhibited by pitocin. Firstly, the hormones (transmitters) liberated by nerve endings are local in action, and although they may enter the general circulation in special circumstances, Loewi (1935) considers they have no functional significance outside the effector in which they are elaborated. This obviously cannot be said of pitocin. Secondly, in the adrenal medulla, the only other endocrine of neural origin, two hormones are produced which are unlike chemically and physiologically, contrary to the condition in the pars nervosa. The cells of the adrenal medulla are under the control of the splanchnic nerves. These are composed of preganglionic fibres, and on stimulation, as might be expected, their terminals around the medullary cells form the hormone (transmitter) acetyl choline, which stimulates the medullary cells to secrete adrenalin (Feldberg, Minz and Tsudzimura, 1934)—a hormone of different chemical composition and diametrically opposed physiological properties. But pitocin and pitressin have similar solubilities, are related to one another chemically (both are amines, Kamm et al., 1928) and, although in some instances they reveal opposed physiological action, they can also produce similar effects, as seen in the following table:

Structure or Substance Affected.	*Effect of Pitocin.*	*Effect of Pitressin.*
Uterine musculature of guinea pig.	Causes contraction.	Nil.
Uterine musculature of rabbit.	Causes contraction.	Causes contraction. (Robson, 1933, 1934.)
Mammalian blood vascular system.	Nil.	Vasoconstrictor.
Avine blood vascular system.	Vasodilator (?). (Morash and Gibbs, 1929.)	Vasoconstrictor. (Morash and Gibbs, 1929.)
Capillaries in web of frog's foot.	Vasoconstrictor.*	Vasoconstrictor.*
Insulin (in mammal).	Antagonizes and produces hyperglycaemia. (Geiling and Eddy, 1928.)	Antagonizes and produces hyperglycaemia. (Geiling and Eddy, 1928.)

* That vasoconstriction in the web of a frog's foot can be caused by pituitary extract was demonstrated by Krogh (1922) and Schneider and Asher (1926), but their work contains no indication as to which of the hormones operates here. The writer finds that intramuscular or intravenous injections of 0·2 c.c. of either pitocin or pitressin cause marked and prolonged constriction of the capillaries and arterioles in the web of *Hyla aurea*. The venules are unaffected.

The above two points can scarcely be dignified with the title of evidence, but they hint that pitocin is not formed by nerve terminals. The following offers something more concrete.

It has been proved (Loewi, 1935, Cannon and Rosenblueth, 1937) by numerous experiments that the nerve fibres of the autonomic system are either adrenergic (i.e., secrete an adrenaline-like body) or cholinergic (secrete acetyl choline). Those of the parasympathetic are cholinergic, while sympathetic fibres generally are adrenergic, but some are cholinergic. The cell bodies of the nervosa nerve fibres are in the nucleus supraopticus. This is sympathetic in character (Kappers, 1928; Ranson, Kabat, and Magoun, 1935; Crouch and Elliott, 1936). In view of this, there is no reason to doubt that the nervosa nerve terminals are either adrenergic or cholinergic and that their function is to control secretion by pituicytes, of pitressin and pitocin. Conclusive evidence that pitocin is not secreted by nerve fibres would be its demonstration in a culture of pars nervosa.

If pituicytes are to be regarded as the elaborators of pitocin and pitressin, correlation of their presence with the presence of the hormones is obviously essential. As has been seen, pituicytes occur throughout the vertebrate series. Pitocin also occurs in all classes of the Vertebrates, but in small quantities in Elasmobranch pituitaries (Hogben and de Beer, 1925). The writer found that intramuscular injections of one dose each (equivalent to 120 mgm. of dried gland each) of *Raja australis* pituitary, into two frogs (*Hyla aurea*) brought about slight constriction of the small capillaries in one case, but had no effect in the other. Control injection of 1·0 c.c. of 0·25% acetic acid had no effect. The constriction was possibly due to pitocin, as Hogben and de Beer could not demonstrate pitressin in skate pituitary by injecting a dose equivalent to 50 mgm. of dried gland into the jugular vein of a cat. They are of the opinion, however, that possibly pitressin is present in such a small amount that it is undetectable in such a dose. It seems from these scanty data that pitressin may be produced, and that pitocin is produced

in small quantity. At any rate the presence of pitocin and pituicytes in Elasmobranchs, pitressin, pitocin and pituicytes in all the other classes, agrees with the view that pituicytes are the secretors.

Summary.

1. The presence of pituicytes has been demonstrated in all the classes of Vertebrates.

2. It has been thought that the pars nervosa hormones may be secreted by nerve endings or pituicytes. Evidence from tissue culture experiments shows that pitressin cannot be formed by nerve endings, and that it is formed by pituicytes.

3. No work has been done to demonstrate pitocin in pars nervosa cultures, but as the nerve terminals of the autonomic nervous system are either adrenergic or cholinergic, and as the pars nervosa nerves are sympathetic, it is reasonable to assume that they are also adrenergic or cholinergic and that the pituicytes are responsible for the secretion of both pitressin and pitocin.

4. Pituicytes and pitocin occur in Elasmobranch pituitary; pituicytes, pitocin, and pitressin occur in all the other classes of Vertebrates. This is also in accordance with the suggestion that the pituicytes are secretory.

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EXPLANATION OF PLATE V.

1.—*Sarcophilus harrisii*, pars nervosa. Showing pituicytes arranged with their long vascular processes extending towards the blood vessel in the lower part of the figure. × 460.

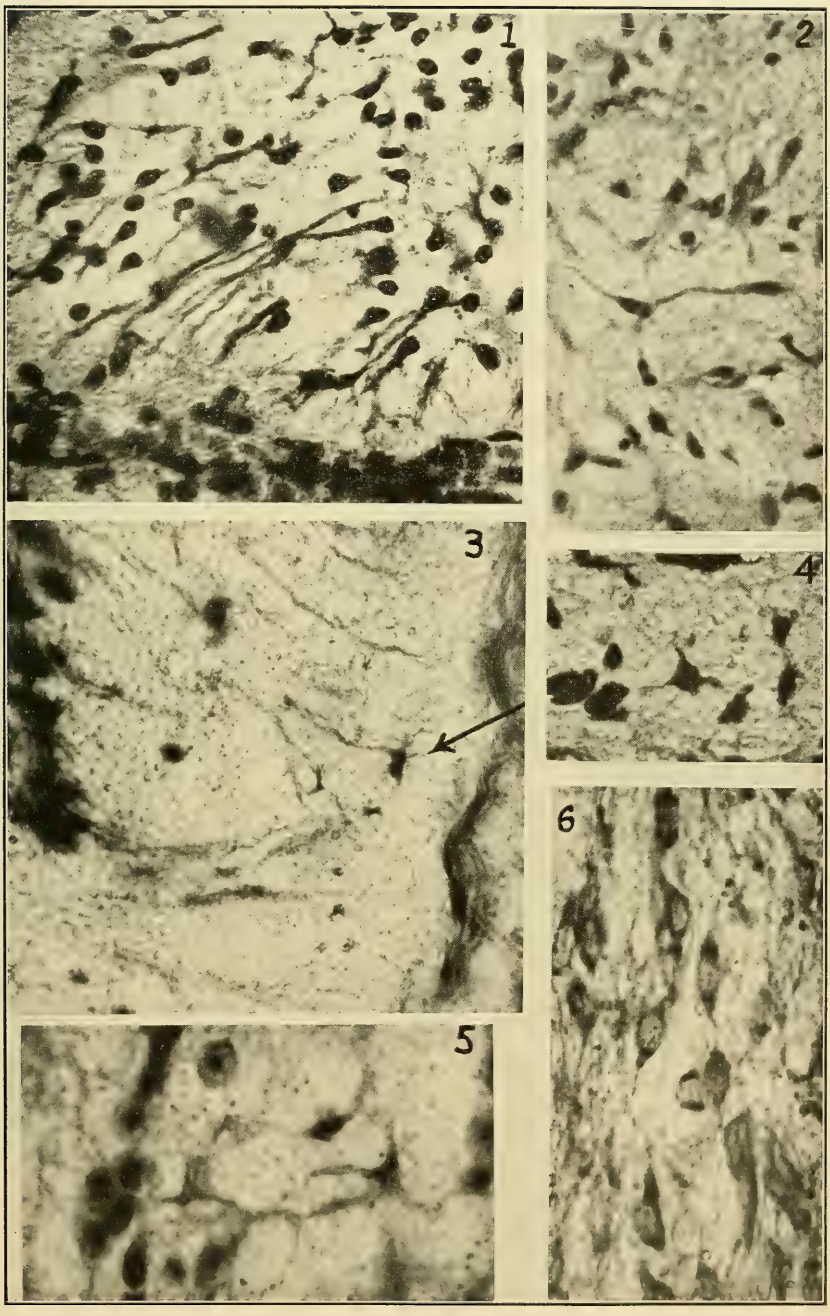
2.—*Gallus domesticus*, pars nervosa. Showing unipolar pituicytes in an interstitial mass. × 620.

3.—*Tiliqua scincoides*, pars nervosa. Multipolar pituicyte with one long process extending towards lumen of lobule on the left. On the right the connective tissue sheath of the lobule may be seen. × 620.

4.—*Hyla aurea*, pars nervosa. Showing poorly impregnated pituicyte. × 620.

5.—*Neoplatycephalus macrodon*, pars nervosa. Three pituicytes exhibiting union and anastomosis of their cytoplasmic processes. Also cell on left can be seen giving off two vascular processes to the blood vessel. × 1,000.

6.—*Raja australis*, pars nervosa. Showing the peculiar pituicytes with their short cytoplasmic processes. × 620.



Pars nervosa in 1. *Sarcophilus harrisii*; 2. *Gallus domesticus*; 3. *Tiliqua scincoides*; 4. *Hyla aurea*; 5. *Neoplatycephalus macrodon*; 6. *Raja australis*.

STUDIES ON THE PITUITARY BODY. II.

OBSERVATIONS ON THE PITUITARY IN DIPNOI AND SPECULATIONS CONCERNING THE EVOLUTION OF THE PITUITARY.

By Mervyn Griffiths, B.Sc.

(*From the Department of Zoology, University of Sydney.*)

(Eight Text-figures.)

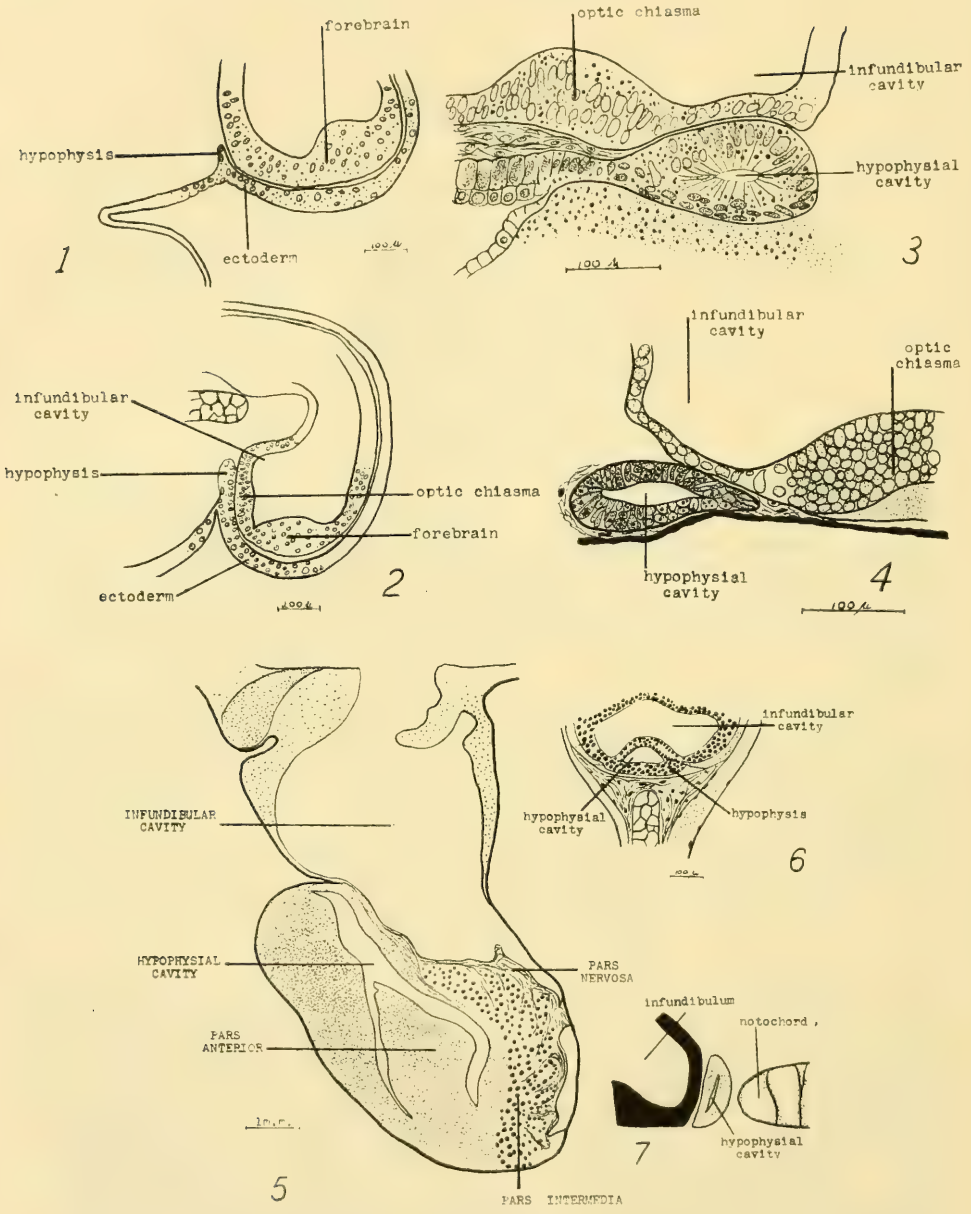
[Read 25th May, 1938.]

Considerable research has been carried out on the comparative anatomy and development of the pituitary body, but this structure in the Dipnoi has been practically ignored until recently. Apart from a brief description of the adult organ by de Beer (1926) and a sketch of the development by J. G. Kerr (1902) in *Lepidosiren*, the only detailed work extant is that of T. Kerr (1933), also on *Lepidosiren*. The present paper on the Australian *Epiceratodus* (*Neoceratodus*) *forsteri* and on *Lepidosiren*, is an attempt to extend our knowledge of the Dipnoan pituitary.

I wish to express my thanks to Professor E. A. Briggs, of this Department, for his advice and for the gift of the *Epiceratodus* material, and to Dr. H. L. Kesteven of Sydney for permission to examine his slides of *Lepidosiren* embryos. Complete serial sections were cut, and stained in Ehrlich's haematoxylin and eosin. The embryonic *Epiceratodus* stages were numbered according to the classification in Semon (1893). The stages examined were 32, 37, 38, 40, 42, 43, 46, 48, and one adult gland. The *Lepidosiren* material was numbered according to the stages in J. G. Kerr (1899). The stages examined were 31, 32, 33, early 36, and late 36.

The Pituitary in Epiceratodus.

Development.—The hypophysis in the earliest stage examined (32) takes the form of a small, solid conical ingrowth (Text-fig. 1) extending in from the deeper layer of ectoderm in the region of the stomodaeum, and lying between the forebrain and foregut. By stage 37 this ingrowth has extended inwards a considerable distance, and lies beneath that portion of the forebrain immediately posterior to the rudiment of the optic chiasma (Text-fig. 2). Flexure of the forebrain is apparent at this stage. At stage 38 the ingrowth commences to expand distally. Stage 40 shows that the expanded portion has developed an eccentrically-placed cavity, situated towards the lower border of the hypophysis. By stage 42 the hypophysis has become oval in shape and the cavity central in position. As in *Lepidosiren*, the cells of the hypophysis in *Epiceratodus* are arranged in a columnar manner about the cavity, with their nuclei at the periphery (Text-fig. 3). In addition, this stage reveals a thinning of the connection between ectoderm and hypophysis. The condition in stage 43 is essentially similar to that in 42, except that the hypophysis is more circular in longitudinal section, and the connection with the ectoderm is thinner. By stage 46, the hypophysis is completely cut off



Text-figs. 1-5.—*Epiceratodus.* 1. Sagittal section of head of embryo, stage 32; anterior end to right. 2. Sagittal section of head of embryo, stage 37; anterior end to right. 3. Sagittal section of infundibulum and hypophysis, stage 42; anterior end to left. 4. Sagittal section of infundibulum and hypophysis, stage 48; anterior end to right. 5. Sagittal section of adult pituitary; anterior end to left.

Text-fig. 6.—*Lepidosiren.* Horizontal section through infundibulum and hypophysis of embryo, late stage 36. Anterior end pointing towards top of page.

Text-fig. 7.—*Protopterus.* Sagittal section of infundibulum and hypophysis of stage 33 embryo. Anterior end to left. (Copied from J. G. Kerr, 1902.)

and is seen as a small rounded body with a cavity which appears circular in longitudinal section, situated beneath the posterior end of the infundibulum. By stage 48 the hypophysis has elongated considerably, entailing a consequent elongation of its cavity. The anterior end of the hypophysis is closely appressed to the postero-ventral surface of the infundibulum just caudal to the optic chiasma (Text-fig. 4). Lateral lobes are not developed.

Unfortunately, intermediate stages between 48 and the adult were not available, but the state of affairs in the adult shows that the hypophysis, along the whole of its length, curls around and becomes intimately united to the posterior face of the infundibulum. The cells of the caudal tip become the pars intermedia, whilst growth of the hypophysis, ventral to the hypophysial cavity, results in the large pars anterior. The whole infundibulum, instead of being directed backwards, as in stage 48, grows vertically downwards into the deep sella turcica of the skull floor. Thus the gland of the adult comes to lie at a considerable distance from the optic chiasma, and the pars anterior takes up an anterior position.

Anatomy.—The adult organ is ovoid in shape, and shows no divisions externally into partes anterior, intermedia or nervosa. The relations of these divisions are shown in Text-figure 5 in sagittal section. Here it is seen that the pars anterior constitutes the main mass of the gland. Dorsally the pars anterior is attached to the membranous anterior portion of the infundibulum. At its caudal end the infundibulum thickens considerably and sends processes down into the posterior end of the adenohypophysis. This thickened region of the infundibulum is the pars nervosa. The cells of the posterior portion of the adenohypophysis are basophil and constitute the pars intermedia. The infundibulum also sends out into the pars intermedia hollow extensions which, in section, appear as open sinuses lined with ependyma. The simple elongated hypophysial cavity of the embryo has, in the adult, developed ventrally directed diverticula, extending down into the pars anterior. Two of these diverticula are seen in Text-figure 5. The hypophysial cavity in *Epiceratodus* appears to be confined to the pars anterior, and does not, as in most vertebrates, separate the pars anterior from the pars intermedia.

The cells of the pars anterior are arranged to form hollow, spheroidal vesicles which are surrounded by connective tissue. The blood supply takes the form of a richly ramifying system of fine capillaries often only of the diameter of one erythrocyte. All blood vessels are peripheral to the vesicles. A peculiar feature of the pars anterior is the presence of a colloid substance which stains with eosin, in the lumina of the vesicles. This suggests a mode of secretion similar to that of the thyroid—if indeed the colloid represents a secretion. First, the "secretion" is passed into the lumen and stored there; from here the route to the blood vessels external to the vesicle may be by diffusion through intercellular spaces in the vesicle wall or through the cells themselves.

The Development of the Pituitary in Lepidosiren.

Only five stages of *Lepidosiren* embryos were examined: 31, 32, 33, early 36, and late 36 (4·7 cm.).

At stage 31 the hypophysis, with a more or less spherical lumen, has taken up its definitive position at the posterior face of the infundibulum, and the connection with the stomodaeal ectoderm has been severed. Stage 32 shows little change from the above except for an increase in size of the hypophysial cavity. By stage 33 the hypophysis has elongated considerably, entailing an elongation of the hypophysial cavity. Early stage 36 reveals that the portion of the hypophysis ventral to the hypophysial cavity has enlarged, so that it is many cells in thickness,

while the region in contact with the infundibulum is thin. A late stage 36 shows that the boundary between the infundibulum and hypophysis has broken down (Text-fig. 6).

T. Kerr (1933) says that the connection between the oral ectoderm and hypophysis breaks down at stage 27, and by stage 29 a lumen develops. But J. G. Kerr states that the hypophysial cavity develops while the connection is still present (stage 29). Probably it is safe to say that the developments in *Epiceratodus* and *Lepidosiren* are similar.

A Note on the Hypophysis in Protopterus.

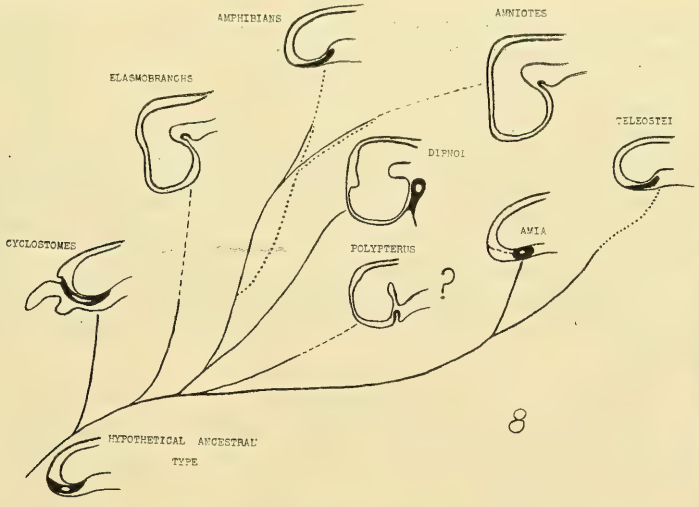
It seems from a figure given by Kerr (1902), of a sagittal section of a stage 33 *Protopterus* embryo, that the development of the pituitary in this form is similar to that of the other Dipnoans. The hypophysis at this stage bears a remarkable similarity to that in stage 33 *Lepidosiren*. Text-figure 7 is copied from Kerr's figure.

Discussion.

The hypophysis may arise as a hollow invagination (Rathke's pouch) or as a solid ingrowth. De Beer (1923, 1924, 1926) has suggested that a causal relation exists between the presence or absence of cranial flexure and the mode of development of the hypophysis. Where cranial flexure is not marked, the hypophysis arises anterior to the stomodaeum and consequently has a long distance to travel in order to make contact with the infundibulum. In all such cases (Cyclostomes, Teleostomes, and Amphibia) the hypophysis arises as a solid ingrowth. When cranial flexure is present the hypophysis arises within the stomodaeum and has only a short distance to travel in order to make contact with the infundibulum. In this case it may take the form of a Rathke's pouch (Elasmobranchs and Amniotes) or a solid ingrowth. The distance the hypophysis has to travel is the real factor concerned, a long distance ruling out the possibility of the hypophysis developing as a Rathke's pouch. In Dipnoi cranial flexure is present, consequently the hypophysis develops within the stomodaeum, but as a solid ingrowth. Now the early stages of the development of the pituitary in Cyclostomes and in Dipnoi are remarkably similar. In both, the hypophysis arises as a solid ingrowth, and in both the hypophysial cavity develops as a split within the solid ingrowth (for simplicity, I shall refer to this as a "schizo"-cavity) whilst the hypophysis is still connected to the ectoderm by a strand of tissue. But the embryonic conditions in the two groups are quite different. Cranial flexure is marked in the Dipnoi, and the hypophysis has only a short distance to travel in order to become attached to the infundibulum. In the Cyclostomes, cranial flexture is absent and the hypophysis has a much greater distance to travel. The Cyclostomes are in many respects degenerate, but they retain more primitive characteristics than any other living vertebrate, and the Dipnoi are an extremely ancient group. Therefore it is possible that the early development of the hypophysis in Cyclostomes represents the primitive mode of formation of the hypophysis and hypophysial cavity, and that this primitive mode has been retained in Dipnoi. It is hardly possible that the Dipnoi possessed the Rathke's pouch type originally and then exchanged it for the solid ingrowth, seeing that they have developed embryonic conditions favourable to the retention or evolution of a Rathke's pouch. I think it likely, therefore, that the Cyclostomes and Dipnoi have both retained the mode of early hypophysis development originally inherited from primitive ancestors which did not possess cranial flexure.

Amia, another fish retaining primitive characteristics, has the same type of hypophysis development, except that the hypophysial cavity develops after the ectodermal connection has broken off (de Beer, 1923). It would seem that the development in Teleostei and Amphibia was of this type, except that the appearance of the schizo-cavity was more and more delayed until it finally failed to develop altogether and resulted in the modern Teleost and Amphibian type. I think it likely, also, that the Rathke's pouch of Elasmobranchii, Polypterini, and Amniotes replaced independently the solid ingrowth–schizo-cavity type, due to the independent occurrence of embryonic conditions which permitted the hypophysis to develop as a pouch. Possibly, however, the pouch of Amniotes replaced the solid ingrowth–minus schizo-cavity type.

De Beer has given a tentative phylogeny of the pituitary based on the structure of the adult gland. He says, "a divergence can be traced between (i) those forms in which the hypophysial cavity disappears, the pars intermedia diminishes and the pars anterior takes up a posterior position, viz., Sauropsida and living Amphibia; and (ii) those in which the hypophysial cavity persists, the pars intermedia retains a considerable size, and the pars anterior is anterior in position". He places *Lepidosiren* in the first group, but *Epiceratodus* obviously comes into the second. The pars anterior is anterior in position, the pars intermedia is large, and the hypophysial cavity is well developed. There is no doubt that these two animals are closely related, therefore a phylogeny based on these criteria is untenable. It is obvious, also, that the hypophysial cavity in Aves and Amphibia is absent for very different reasons.



Text-fig. 8.—Scheme of evolution of the pituitary. (See text.)

I think at this stage a tentative phylogenetic table based on corresponding embryonic stages will be found useful. In the accompanying scheme (Text-figure 8) the continuous line means that the members on that line of evolution possessed the solid ingrowth–schizo-cavity type of development; the broken line indicates the possession of the Rathke's pouch which replaced the first-mentioned type; and the dotted line means that the members of this line possessed the solid ingrowth derived from the first type, but failed to produce the schizo-cavity. The develop-

ment of the pituitary in *Polypterus* is not known in detail, but J. G. Kerr (1919) gives a figure of a sagittal section of a stage 32 *Polypterus* embryo, in which the hypophysis is depicted as a pouch. It is to be noted that in this scheme the distances between the points of origin of the various lines of evolution are not meant to be proportional to time intervals.

Now we must consider the question of proboscis pores (Goodrich, 1917; de Beer, 1926). Undoubtedly the proboscis pores of *Amphioxus*, Elasmobranchs, and Sauropsida are homologous. If we accept the view that Rathke's pouch replaced the solid ingrowth independently in Elasmobranchs and Amniotes, this homology of the proboscis pores needs explanation. Very probably in the earliest craniates, where the union of hypophysis and infundibulum had not evolved, the hypophysis arose as a pouch into which the cavities of the premandibular somites opened by means of proboscis pores, as happens in *Amphioxus*. Later, when the hypophysis-infundibulum combination was evolved (cranial flexure very likely being absent and the hypophysis arising anterior to the stomodaeum), the hypophysis was constrained to develop as a solid ingrowth, owing to the distance it had to travel to meet the infundibulum (de Beer has already advanced speculations similar to the above). The premandibular somites here could not communicate with the cavity of a Rathke's pouch. However, I should say, when embryonic conditions changed (independently) in Elasmobranchs and Sauropsida and permitted the hypophysis to develop as a pouch, the genes (hitherto latent) responsible for the formation of proboscis pores were able to express themselves in favourable cases.

Summary.

1. The anatomy and development of the pituitary in *Epiceratodus*, and portion of the development in *Lepidosiren* are described.

2. The similarity between the hypophyses of stage 33 *Protopterus* and *Lepidosiren* embryos is pointed out.

3. The early stages of development of the pituitary in Cyclostomes and Dipnoi are very similar, in spite of the fact that embryonic conditions in Dipnoi favour the retention or evolution of a Rathke's pouch. Reasons are brought forward to substantiate the view that the mode of development in these two groups (the solid ingrowth–schizo-cavity type) is the primitive central type from which the solid ingrowth–minus hypophysial cavity type and Rathke's pouch were derived.

4. The relation of the concept of the primitive nature of the solid ingrowth–schizo-cavity type of development, to the concept of the homology of proboscis pores is discussed.

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NOTES ON *TRICHOPSIDEA OESTRACEA* (NEMESTRINIDAE) AND *CYRTOMORPHA FLAVISCUTELLARIS* (BOMBYLIIDAE)—TWO DIPTEROUS ENEMIES OF GRASSHOPPERS.

By Mary E. Fuller, B.Sc., Council for Scientific and Industrial Research.

(Plate vi; 19 Text-figures.)

[Read 25th May, 1938.]

Of the various species of flies which have been bred from material collected during the Council's grasshopper investigations, two have been found to attack the living hoppers at some stage of development. The first, *Trichopsidea oestracea*, is known as a grasshopper parasite (Noble, 1936), and the second, *Cyrtomorpha flaviscutellaris*, is recorded for the first time. These two larvae are the first to be described of the Australian Nemestrinidae and Bombyliidae.

Trichopsidea oestracea Westwood.

Trichopsidea oestracea was described by Westwood in 1839, and Mackerras (1925) gave a detailed description, to which my specimens conform. The species is widely distributed throughout Australia, and is recorded also from New Guinea. Mackerras notes that the flies are active and difficult to capture, and that nothing is known of their feeding habits or life history.

A. S. Olliff (1891) records finding a large dipterous larva in locusts, but he did not breed the fly. He gives a small drawing of what is undoubtedly the larva of *Trichopsidea oestracea*, but it is printed upside down. Noble (1936) found the larvae in plague grasshoppers (*Chortoicetes terminifera*) from Hay, N.S.W., and in a species of *Parelytrana* from Gulargambone, N.S.W. He reproduces Olliff's drawing of the larva, and also figures it upside down. He does not describe the larva, and notes that the species has not previously been recorded as a grasshopper parasite, and that nothing is known of the early stages of Australian Nemestrinidae.

Little is known of the early stages of Nemestrinidae in any part of the world. The life history and immature stages of the European species *Hirmoneura obscura* Meig. which is parasitic on the beetle *Rhizotrogus solstitialis* has been described by Handlirsch (1883), and the eggs and first stage larva of the Chilian *Hirmoneura articulata* Ph. by Stuardo.

Notes on Larval Habits.

During October, 1935, one full-grown *Trichopsidea* larva was obtained from the eastern plague grasshopper, *Chortoicetes terminifera*, collected at Yass, N.S.W. In the same season (1935–36) Mr. A. L. Tonnoir released a number of this species of hopper, taken locally, in a field cage. At the end of January several *Trichopsidea* larvae were found in the cage. These remained in the larval stage for six months, when they were transferred to a room kept at 23°C. in order to hasten their metamorphosis. Some of these larvae pupated early in August and emerged at the end of the month, the pupal stage under these conditions occupying 20 days.

The others did not pupate until December and emerged in January. Thus, even at a high and uniform temperature, they remained larval for eleven months.

With the exception of one which was dug from a grasshopper egg-bed at Jugiong, N.S.W., all larvae used in this study were obtained from adult hoppers taken in the field and from which they emerged when these were placed in cages. They were all full-fed and sluggish, being practically incapable of progression at this stage. One early stage Nemestrinid larva was dissected from the abdomen of a grasshopper, *Parelytrana* sp., by Mr. Tonnoir. It is not certain that this is the early stage of *Trichopsidea*, but its structure suggests that it is. Further evidence is lent by the fact that the host was collected in the Gulargambone district, where Noble obtained a *Trichopsidea* larva from the same species. This particular species of host, *Parelytrana* sp., is not wide-spread, being confined to the western plains.

In December, 1936, several species of common grasshoppers occurring in Canberra were collected and placed in field cages by Mr. Tonnoir, one species to each cage. During June and July, 1937, the soil in these cages was sieved for eggs, and in several cages the large larvae of *Trichopsidea* were found. The numbers were as follows: *Phaulacridium vittatum* 7, *Gastrimargus musicus* 6, *Austroicetes pusilla* 4, *Macrotona securiformis* 1. *Trichopsidea oestracea* evidently parasitizes many species of grasshoppers besides the plague species *Chortoicetes terminifera*. The percentage parasitism doubtless varies with the host-species and with various localities, but in Canberra, for all species attacked, is estimated roughly at about 5%. The larvae are thus fairly abundant, in striking contrast to the scarcity of the adult, which is seldom seen in the field and is comparatively rare in collections.

The Young Larva.

The larva (Plate vi, fig. 1) was dissected from the abdomen of a species of *Parelytrana* by Mr. Tonnoir, who noted that it was slender, worm-like and very active. In striking contrast to the full-grown larva, it is elongate and smooth, resembling in general form the newly hatched *Hirmoneura* larva (Handlirsch, 1883; Stuardo, 1935) which, however, is only 2 mm. in length and has a pair of elongate hooked "locomotor organs" on each segment. Taking into consideration its size and the lack of locomotor organs, the larva described below was probably in its second instar.

The length was nearly 6 mm. and the greatest width less than 1 mm. It is white, slender, cylindrical, slightly wider in the middle and narrowed at each end, the tapering being most pronounced at the posterior end. The segments are elongated, particularly the last three, which seem remarkably flexible or mobile. The posterior extremity is cut off abruptly, the spiracles being situated on a flat vertical face with a small circumference. The surface of the body is entirely devoid of hairs or protuberances and has a perfectly smooth appearance although the skin actually has a fine transverse wrinkling.

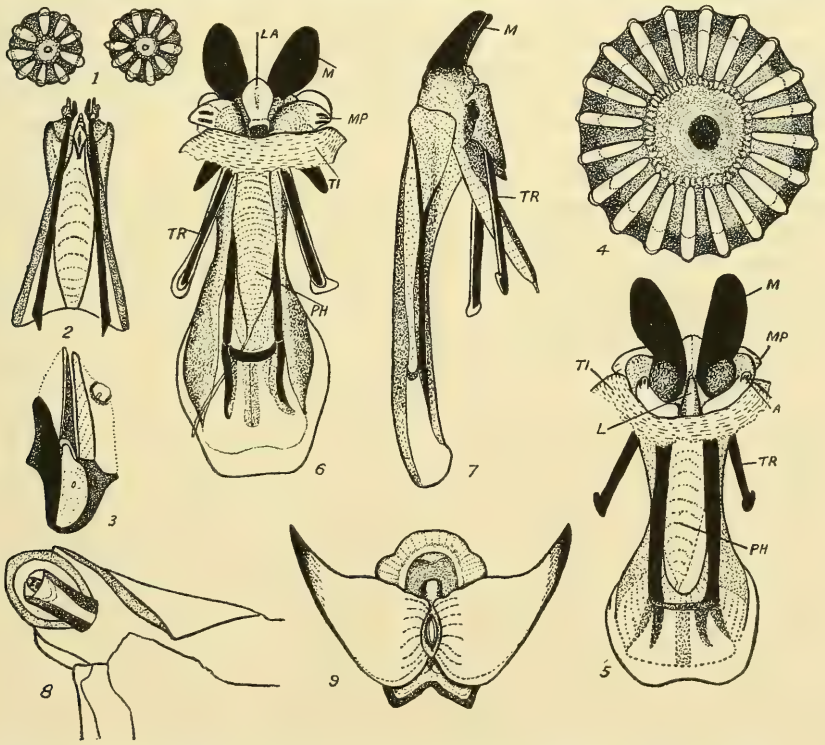
There are three thoracic and eight abdominal segments visible. The head is extremely small. The segmentation is not well defined, owing to the absence of bands of spines or papillae, and the constriction is very slight. The only spiracles visible are those at the posterior end (Text-fig. 1). They are a pair of small, lightly chitinized circular plates, set fairly close together. Each has nine or ten elongate-oval slits radiating from the centre like the spokes of a wheel. They are not protected by hairs or projections and lie flush with the flat surface.

The mouth-parts are small and lightly chitinized, being yellowish or light brown. The bulk of the head and mouth armature is enclosed within the thoracic

segments, only the mandibles and maxillae being permanently protruded (Text-fig. 2). The head and mouth-parts appear to be similar in structure to those of the first-stage larva of *Hirmoneura*. The epicranium is represented by a dorsal elongate plate of fairly light chitin, with the lateral edges strengthened and turned down over the pharynx. Anteriorly these converge as chitinous bars to the base of the labrum, whilst the lateralia arise from the epicranium lateral to them, curving forwards and inwards and forming a cup-like depression in which the mandibles and maxillae are set. The epicranium ends anteriorly in the small nose-like labrum. The pharynx is a wide shallow trough, with the labium attached to its anterior end. The tentorial rods are attached to the epicranium at its anterior end on each side of the pharynx, and the rounded curved ends are associated with the base of the mandibles. The mandible and maxilla are closely united, the mandible being small, and the maxilla elongate and pointed (Text-fig. 3). These are the most anterior of the mouth-parts, projecting well in front of the labrum and labium.

The Full-grown Larva.

The following description is from prepupal larvae (Plate vi, figs. 2 and 3) which had left the hoppers and buried themselves in the soil. They measured



Text-figs. 1-9.—*Trichopsidea oestracea*.—1, Posterior spiracles of young larva, × 170. 2, Head of young larva, × 75. 3, Maxilla and mandible of young larva, × 225. 4, Posterior spiracle of full-grown larva, × 135. 5, Head of larva, dorsal view, × 30. 6, Head, ventral view, × 30. 7, Head, lateral view, × 32; *a*, antenna; *l*, labrum; *la*, labium; *m*, mandible; *mp*, maxillary palp; *ph*, pharynx; *ti*, thoracic integument; *tr*, tentorial rod. 8, Antenna, × 160. 9, Posterior end of pupa, × 37.

from 9 to 17 mm. in length, and the greatest width of the largest ones was 5 to 5½ mm. The larva is broadest in the middle and narrows at each end, but most anteriorly. It is convex, with the stronger curve ventral, and a slight ridge along each side. The posterior end is truncated, the last segments curving upwards. The larva is robust, tough and leathery, yellowish-fawn to ochre in colour. Superficially it resembles the larva of *Hirmoneura* figured by Handlirsch and by Brauer.

The Head and Mouth-Parts (Text-figs. 5, 6, 7).—The whole of the head structure is enclosed within the thorax. The epicranium is an elongate plate of transparent chitin widened posteriorly, and strengthened by a pair of longitudinal chitinous bars, converging anteriorly to the labrum and united towards the posterior end by a short transverse bar. The lateral edges curve downwards and slightly under. Anteriorly the edges expand and curve laterally to form the lateralia. A pair of comparatively short tentorial rods run from the base of the labium on each side of the pharynx ventrally. The pharynx is a strong elongate trough-like organ about three-fourths the length of the head. The labium is connected to the anterior end of the pharynx and has a salivary duct opening into it. It is a small delicate organ lying between the mandibles ventrally, devoid of hairs, and visible externally on the larva. The labrum is a short nose-shaped projection at the end of the epicranial plate between the base of the mandibles and above the labium.

The antennae (Text-fig. 8) are very small and difficult to detect, being hidden by the edge of the thoracic integument. They are situated on the edge of the lateralia, and are flattened against the surface close to the outer edge of the base of the mandibles. There are three segments, two lying parallel to the surface and directed laterally, pressed close against the surface, and a small dome-shaped apical segment.

The mandibles are large, black, and shovel-shaped, the dorsal side being convex. These project permanently on the larva, but the bases extend some way inside the thorax, well behind the labrum and labium. The maxilla is closely associated with the mandibles. It is perfectly smooth and somewhat reduced, being very short and rounded, appearing as a small dorso-lateral bulge beside the mandible. The palp, however, is very large, and is conspicuous on the ventral aspect of the larva projecting laterally below the mandibles.

The segments are well marked, there being three thoracic and nine abdominal, each but the last being divided by longitudinal furrows into dorsal, lateral and ventral areas. Dorsally each thoracic segment has a thick fold at the anterior border. On this are borne 10 to 12 short, rounded protuberances running transversely right across the dorsum. On the first segment they coalesce into one narrow ridge. Also on the first segment are two series of four protuberances posterior to the fold. The lateral regions bear five protuberances in the first segment and four in the others, the one nearest the ventral edge being the largest. On the ventral areas each segment has six papillae, a pair on each side of the mid-line and one further out. There is an anterior extension of the first segment enveloping the base of the mouth parts and forming a small pseudocephalon.

Dorsally each abdominal segment has a pair of crescentic ridges with the convexity facing posteriorly, one on each side of the mid-line. These are less conspicuous on the last three segments. In the middle of each segment running transversely right across is a series of twelve flattened projections, forming a low broken ridge, and joining on the 6th and 7th segments to form a continuous ridge. Laterally there are four papillae, three in a transverse line and a larger one anterior to these and nearer the ventral edge. These large lateral papillae form a longitudinal line down the larva ventro-laterally. Ventrally in a transverse

series across the middle are eight papillae, four smaller grouped at the mid-line, and the rest larger and more lateral. Anterior to this series and near the anterior border is a pair of large papillae, more elongate than any others, projecting slightly backwards.

The dorsal face of the eighth segment (Plate vi, fig. 5) is occupied chiefly by an area which is almost circular in outline, and slightly raised. There is a slight depression towards the posterior edge and the spiracles are situated anterior to this, lying flush with the surface. Posteriorly there is a row of six large, prominent, blunt projections, forming the terminal extremity of the larva. The two outermost prominences are the terminations of the lateral ridges of the eighth segment. The ventral area of the eighth segment is reduced to a narrow sternite bearing two pairs of very flattened and inconspicuous papillae. The papillae on the dorsum are also inconspicuous, there being three on each side of the spiracles and four posteriorly in front of the large terminal projections.

The ninth segment is entirely postero-ventral, having a steeply inclined surface running from the sternite of the eighth segment to the base of the terminal projections. It is devoid of papillae, but the anus, a longitudinal slit situated on it, has two rounded swellings each side.

The posterior spiracles are conspicuous circular, chitinous plates placed fairly close together (Text-fig. 4). They are the only spiracles present, the larva being, like that of *Hirmoneura obscura*, metapneustic. The slits are the length of half the radius, and radiate like medullary rays all round the circle from half-way to the centre. There are twenty slits to each spiracle, and they are narrow and elongate. There is a smaller, inner circle, half the radius of the plate. This is formed of pale, spongy, dull chitin, whilst the outer ring is of smooth brown shining chitin. The inner circle is depressed towards the centre which is occupied by the "button", a black chitinous mass. The felt chamber is short and has a thick central core, the inward extension of the inner circle of the spiracle. Laterally on every segment from the first thoracic to the seventh abdominal there is a very minute vestigial spiracle. It occurs just above the large rounded protuberance near the ventral anterior edge of the lateral area, and is not visible on the larva. By clearing and staining it may be detected as a small unchitinized spot with a very slender thread-like tracheole connecting it with the main tracheae.

The Pupa.

The pupa (Plate vi, fig. 4) is very similar to that of *Hirmoneura obscura*. It measures 15 to 16 mm. in length, the female being rather broader than the male pupa. It is tawny yellow to ochre in colour. The ventral surface of the abdomen is strongly convex, as in the larva, and the end segments turned up in the same manner. The following description is from a male pupa.

The thorax is short, the head and thorax being only 5 mm. long. The leg- and wing-sheaths do not extend beyond the first abdominal segment. There are no bristles on the head and thorax which are of wrinkled chitin. The antennae are small, flattened, well separated and pointing downwards and slightly outwards. The thoracic spiracles are just behind the head, and have the appearance of a shining bead of dark brown chitin. The slit is near the base of the bead and runs transversely on its posterior aspect. The ends are curved strongly. At the base of the wing-sheaths is a small elevation. The suture runs longitudinally down the dorsum of the head and thorax, and transversely across the head.

The abdominal segments are marked into dorsal, lateral and ventral areas by furrows. The lateral areas form a ridge down each side. The middle of each

segment except the last is encircled by a girdle of spines. These are stiff and brown, increase in length towards the side, and are longer ventrally than dorsally. A few are bifid. On the lateral areas there are three in the row which are greatly lengthened and have hooked ends, the hooks curving forwards. Each lateral area on segments one to seven has a spiracle towards the ventral edge. These are also like shining beads and are in line with the thoracic spiracles. The slit is, however, situated on the anterior aspect, in the form of a transverse curving line. The eighth segment has at its terminal end, in the position of the "aster" of Tabanid larvae, a shining dark-brown chitinous structure like an outspread pair of wings raised on a disc, which has a pair of projections postero-ventrally below the "wings" (Text-fig. 9). A similar structure occurs in *Hirmoneura*. Below this structure and a little anterior to it is a pair of strong short spines with a smaller one beside them. These form part of a broken girdle of very minute spines round the segment.

The female pupa differs chiefly in having a smaller head, a wider abdomen, and the terminal "wings" are not outspread, but half raised.

Cyrtomorpha flaviscutellaris Roberts.

Cyrtomorpha flaviscutellaris was described by Roberts (1919) from the Swan River, Western Australia, and has only been recorded from the southern part of that State. Nothing was known of its breeding habits until Dr. K. Key found it associated with grasshopper egg-beds. Many genera and species of Bombyliidae are known to feed on grasshopper eggs in the larval stage in other parts of the world. A list of these is given by Uvarov (1928). Although the breeding habits of many species are known, there is very little literature on the structure of the early stages. Riley (1880) described the larva and pupa of *Systoechus oreas* and *Triodites mus*, two species which feed on hopper eggs in North America. Nothing has been published on the larvae of Australian Bombyliidae.

Notes on Larval Habits.

In May, 1936, Dr. Key collected several larvae of *Cyrtomorpha* in the egg-beds of *Austroicetes cruciata*, the plague grasshopper in the south of Western Australia, at Nungarrin, W.A. The egg-bed was dense and the egg-pods were at all stages of development. The *Cyrtomorpha* larvae were found in rather loamy soil close to and between empty pods, the contents of which they had doubtless destroyed. Later in the season further consignments of egg-pods collected by Mr. C. Jenkins and Mr. L. J. Newman at Bencubbin, Kunnunoppin and Kellerberrin were received, containing more specimens of *Cyrtomorpha* larvae.

On 26th June, 1936, two larvae received from Dr. Key were placed in the constant temperature room (22°C.). One pupated after nearly four months at this temperature, being kept in the dry soil in which it was found. On 12th November the fly emerged, after 24 days in the pupal stage. The other larva did not pupate and was removed from the hot room in January to the laboratory, where it remains still in the larval stage after 14 months. On 26th August four larvae were obtained from the original material and placed in the hot room. They had all pupated by 15th December, and all emerged in the week ending 5th January, 1937.

Nothing is known of the early stages of the larvae, or the length of their feeding stage.

The Full-grown Larva.

The larva (Plate vi, fig. 6) measures from 5½ to 9 mm. in length when extended. The normal position is curled round with the head and posterior ends touching, the larva straightening out only when disturbed, and then quickly springing back

into the curved position. It is thick-set and broad, widest at the anterior end, tapering slightly to the posterior. The larva is sluggish and seems incapable of moving about. When forcibly straightened so that the ventral surface is visible, the segments appear to be narrower ventrally and the skin more delicate. The colour is deep cream, with the skin very thin and transparent, so that the internal organs are visible, the colour being due to these. The skin has a fine transverse wrinkling.

Just beneath the skin each segment is invested with a thick layer of opaque spongy white fat-body which, however, resists all the common fat solvents tried. Owing to the skin being tightly stretched on the dorsal surface by the curved attitude of the larva, the ring of fat-body in each segment is distinct as a clear yellowish substance visible between each segment. Riley describes a similar appearance in *Systoechus*. Ventrally the whole surface appears opaque-white, owing to the contraction of the segments. Great quantities of oil are released from the white layer when the thin integument is damaged. In the thoracic segments the fat-body is not so close to the surface.

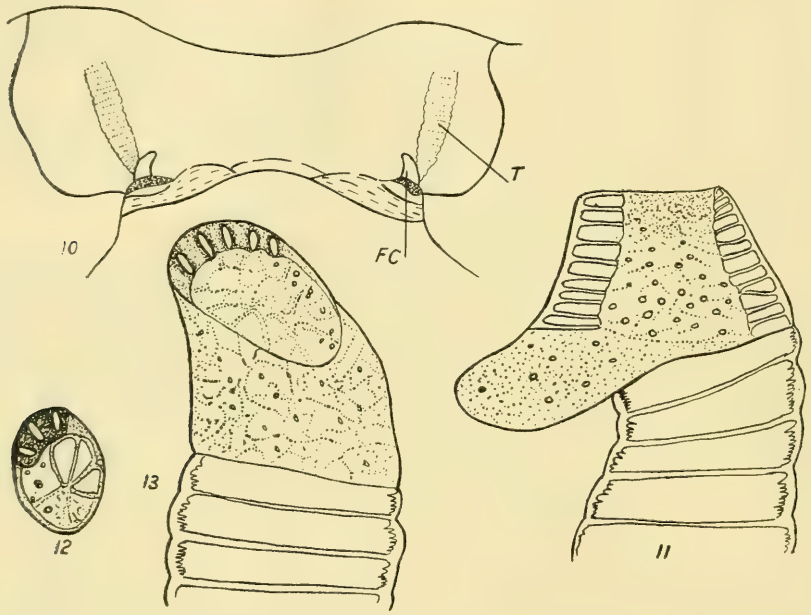
The head is small and enclosed within the first thoracic segment, only the tips of the mouth-parts protruding (Text-fig. 14). The epicranium is elongate and narrow, widening a little at the posterior end. It is strengthened by a pair of longitudinal narrow chitinous bars which expand at the posterior end. Ventrally there is a pair of tentorial rods slightly shorter than the epicranium, converging anteriorly at the base of the maxillae. The epicranium ends anteriorly in a bi-lobed structure, each lobe of which is bulbous and opaque greyish-white in the living larva. It is a noticeable feature of the head and cannot apparently be retracted. It appears to be characteristic of Bombyliid larvae. Malloch figures it in *Sparnopolius fulvus*, and Séguy in *Bombylius fugax* where it is bifid, as in *Cyrtomorpha*. The chitinous struts of the epicranium run up into the two lobes. The structure probably represents the labrum, as the undersurface has the characters of the epipharynx. Riley mentions it in *Systoechus* and *Triodites*, and considers that it may represent the labrum. Ventrally there is a thin, narrow chitinous plate, the labium, bearing a pair of bristles, probably the labial palps. This just projects beyond the margin of the first segment on the ventral surface.

At the sides of the head, just lateral to the base of the large dorsal lobes, are the antennae (Text-fig. 15). These consist of a small clear membranous area bearing a slender, elongate cylindrical segment with minute sensillae at the tip, and close to it at the base a tiny brown dome-shaped projection.

The maxillae are well-developed, large and chitinous, being probably the most functional and active of the mouth-parts (Text-fig. 16). They are broadly triangular in shape, curved dorsally, and with a blunt tip. They project well forward, being considerably anterior to the bilobed labrum. Dorso-laterally each bears a large, conspicuous palp. This arises from a clear patch in the strong chitin of the maxilla and consists of an elongate segment bearing a group of small sensillae at the top. The base of the palp is surrounded by a group of five bristles, one being longer than the rest. The mandibles are small and closely associated with the maxillae (Text-fig. 17). Each is slender and styliform, with four small serrations at the tip. They arise from a strong chitinous mass which is curved back ventrally and lies between the maxillae at the ends of the tentorial rods.

The segmentation of the body is well marked, owing to the clear band between the fat-body in each segment. There are three thoracic and nine abdominal segments. The lateral ridge is poorly developed but can be distinguished clearly in the last few segments. In the eighth it is a well-marked lateral projection.

This segment has also four short blunt projections on the posterior margin ventrally. The ninth segment is short and slopes off to a rounded tip. It bears a series of six little blunt papillae dorsally, and on the ventral surface the anus appears as a small longitudinal slit. There is a pair of exceedingly fine and delicate hairs ventrally on each thoracic segment, situated one on each side of the mid-line near the lateral edge. The rest of the body appears to be entirely devoid of hairs.

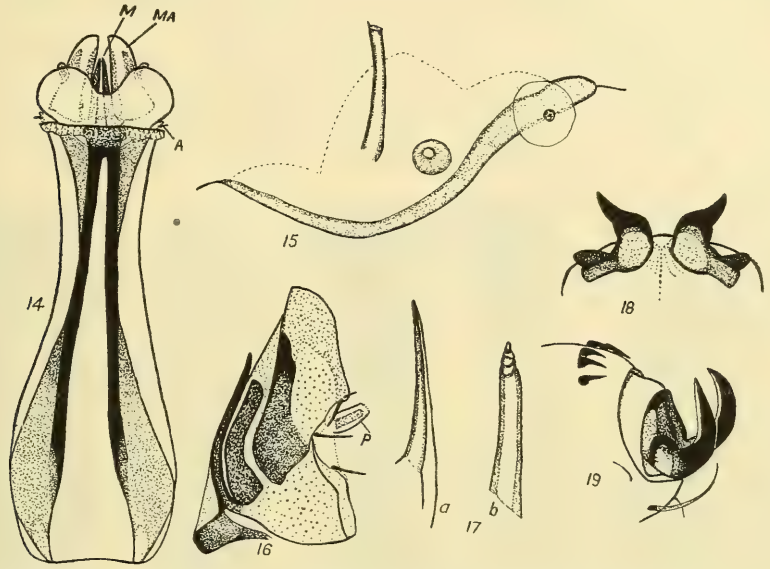


Text-figures 10-13.—*Cyrtomorpha flaviscutellaris.*—10, Dorsum of eighth abdominal segment (cleared), × 50; *fc*, felt chamber; *t*, trachea. 11, Felt chamber of posterior spiracle, × 450. 12, Posterior spiracle, × 450. 13, Anterior spiracle, × 570.

The spiracles are exceedingly minute, and of colourless delicate chitin like the rest of the integument. The posterior pair is situated on the penultimate segment near its posterior border and at the junction with the lateral swelling (Text-fig. 10). The spiracular area is visible as a small skin fold, to which a tracheal trunk is readily traced. The spiracle itself is completely concealed, as it lies on a narrow fold facing posteriorly, so that the plate is vertical to the dorsal surface of the body, and is moreover further enveloped by folds of skin. The felt chamber is comparatively large and roughly triangular in shape (Text-fig. 11). The spiracular plate is oval in shape, with three small slits at one end (Text-fig. 12). Malloch notes that the spiracles of Bombyliid larvae are small and difficult to detect, but Riley and Séguy figure them conspicuously on *Systoechus* and *Bombylius*.

The anterior spiracles, situated laterally on the first thoracic segment, are concealed in a similar manner to the posterior spiracles. The plate is slightly larger and easier to detect owing to the greater number of slits (Text-fig. 13). It is interesting to note that in *Systoechus* and *Bombylius* the anterior spiracles are also larger than the posterior, and have a similar structure to those of *Cyrtomorpha*.

Both Malloch and Riley state that lateral abdominal spiracles are absent. In *Cyrtomorpha* there is a very minute spiracle on each side of abdominal segments one to seven. It appears as a tiny pore surrounded by a ring of strong chitin. The felt chamber is visible beneath the skin with a branch leading to the tracheae.



Text-figs. 14-19.—*Cyrtomorpha flaviscutellaris.*—14, Head of larva, × 65; *a*, antenna; *m*, mandible; *ma*, maxilla. 15, Antenna, × 335. 16, Mandible and maxilla, × 170; *p*, palp. 17, Mandible, × 170; *a*, lateral view; *b*, ventral view. 18, Head armature of pupa, × 20. 19, Posterior end of pupa, × 20.

The Pupa.

The pupae (Plate vi, fig. 7) vary a little in size, like the prepupal larvae, the largest measuring 8 to 9 mm. in length. The abdomen is strongly curved, as in the larval state, but the thorax is comparatively straight. The colour is at first greyish-white, changing through brown to almost black as development proceeds. The actual pupal skin is transparent and colourless, so that the colour is due to the developing nymph within. The tips of the leg and wing sheaths extend to the second abdominal segment, the thorax being short in comparison with the abdomen.

The pupal armature is as follows: On top of the head is a pair of strong pointed thorns projecting upwards, and connected with them is a pair of lower, lateral, smaller blunt projections (Text-fig. 18). The whole structure is dark brown and of very strong chitin. All other Bombyliid pupae described have six or eight spines on the head, including a pair at the base of the proboscis. *Cyrtomorpha*, however, lacks all but the two pairs, but there are, in addition, several small, fine hairs, which are situated one behind each of the large cephalic thorns, a pair on the head below the armature, and a series of six across the middle of the prothorax dorsally. Abdominal segments one to three bear six long brown spines dorsally in a transverse series, those on the first segment being the largest and having hooked ends. On segments four to seven the spines are replaced by short hooks, which are strongly curved, and become progressively larger from each segment to the next. On the lateral areas of segments one to

seven there is a pair of long straight spines. Ventrally the skin is more than usually delicate and membranous, and there is no armature, with the exception of a pair of small hairs on the posterior border of segment seven. The eighth segment is small, and bears at its extremity a pair of heavy chitinous plates from which arise a pair of very strong, black, upwardly-curved hooks (Text-fig. 19). These resemble the terminal armature in *Anastoechus*.

The thoracic spiracle is very small, situated laterally on the fore border of the prothorax, just behind the head. It appears as a small brown spot raised on a slight swelling of transparent skin. Three slits arranged fan-wise occupy the spiracular plate. The abdominal spiracles are still smaller and occur on the lateral area near the fore-border of segments one to seven. The opening is a single slit facing posteriorly.

Acknowledgements.

The author is indebted to Mr. A. L. Tonnoir and Mr. L. J. Newman for material, to Dr. I. M. Mackerras for information on the systematics, and to Mr. W. J. James for the photographs.

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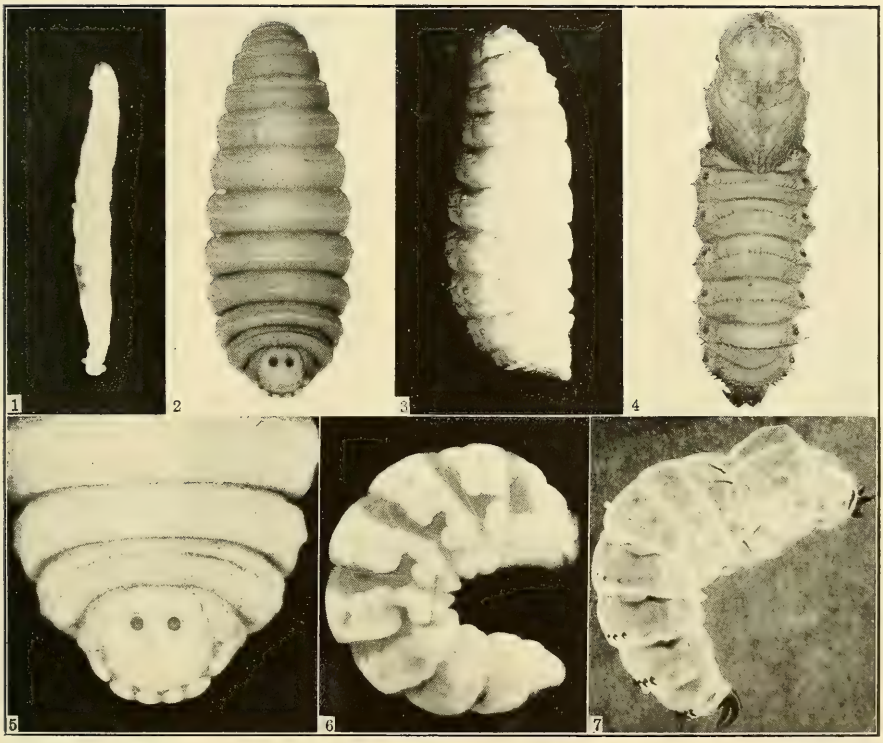
DESCRIPTION OF PLATE VI.

Fig. 1.—The young larva of *Trichopsidea oestracea*. × 7.
Fig. 2.—Full-grown larva of *T. oestracea*, dorsal view, × 2·5.
Fig. 3.—Full-grown larva of *T. oestracea*, lateral view, × 2·5.
Fig. 4.—Pupa of *T. oestracea*, ventral view, × 3·1.
Fig. 5.—Posterior end of larva of *T. oestracea*, showing spiracles, × 5·6.
Fig. 6.—Full-grown larva of *Cyrtomorpha flaviscutellaris*, × 5.
Fig. 7.—Pupal skin of *C. flaviscutellaris*, × 5.



1-5, *Trichopsidea oestracea*.—6-7, *Cyrtomorpha flaviscutellaris*.

A LIST OF THE INSECT ECTOPARASITES RECORDED FROM AUSTRALIAN BIRDS AND MAMMALS.

By Gordon B. Thompson and N. J. B. Plomley, B.Sc.

[Read 25th May, 1938.]

Although several lists of Australian ectoparasites have appeared from time to time, notably those of Cleland (1922), and of Johnston and Harrison (1913, 1913*a*, 1913*b*), these have dealt either with forms from a particular host-group, or with a particular group of ectoparasites. It is felt, therefore, that it would be of advantage to have a single reference list to all the insect ectoparasites. In every instance the original description has been consulted. No Cimicidae, Polyctenidae or Arixeniidae* have as yet been recorded from Australian hosts.

The list is in two sections. In the first, Section A, the parasites are considered in detail, while in the second, Section B, the ectoparasites are merely listed under their hosts. The fauna lists used in the compilation of these records are those of Mathews (1927, 1930) and of Iredale and Troughton (1934), and an attempt has been made in both sections to refer the host-name given in the record to these authors' findings on host synonymy, while they provided final judgment if question arose as to the occurrence in the Australian fauna of some host considered in previous lists. A host-group abbreviation is given after each corrected host-name (omitted in Section A for Nycteribiidae and Streblidae, since all are parasites on Chiroptera). These corrected host-names appear after the references to each parasite species and, where lacking, the host data given have been indeterminable or wanting. In Section B only the corrected host-name is given, such indeterminable records being omitted.

Though a uniform method of treatment has been aimed at in Section A, it has been found that each parasite group has, to some extent, presented special problems in listing; thus the greater number of the Mallophaga have been described from skins in museums, and so locality records are omitted in this group for the most part. In listing we have considered only those records which seem of interest from the point of view of the systematics and host-distribution of the parasite in question, and so references to lists, general works and monographs, together with a number of less important papers, have been omitted, unless they throw additional light on these questions; the more important of such publications are listed in the bibliography. Where a parasite has a distribution outside Australia, such extralimital records are not listed unless essential to the systematics, and when given reference to, host and locality are frequently omitted. When a reference includes extralimital records (either of host or of locality), or when records are repeated, they are omitted from the listing; i.e., the reference is quoted only in part. We would emphasize particularly that references to obvious straggling have been omitted. Straggling, of course, can only be said to occur

* These insects are in all probability not true parasites.

when close host-parasite specificity obtains, as in the Mallophaga and Siphunculata. Such records serve no useful purpose and no argument can be advanced in favour of their perpetuation, for they serve only to obscure and to confuse the ectoparasite record, especially in its application to phylogenetic studies and to medical and veterinary problems.

It is to be noted that all parasite records from domesticated and introduced animals are omitted whether the parasite has been introduced with its host or has been derived from some native host, as are records of introduced parasites upon native animals. Thus Rothschild (1916) records *Ctenocephalides felis* (Bouché) from *Aepyprymnus rufescens* Gray, while Jordan and Rothschild (1922) record *Pygiopsylla rainbowi* (Rothschild) from *Rattus rattus* L. Johnston and Harrison (1913, 1913*a*, 1913*b*) have listed many of the Mallophaga and Siphunculata recorded from domesticated and introduced animals in Australia. Such forms as the sparrow and starling, the "brown" and "black" rats, and the house mouse are considered as introduced.

The Diptera are listed under the families Hippoboscidae, Nycteribiidae and Streblidae. The Hippoboscidae of the region are in a very confused state systematically, and we are greatly indebted to Dr. J. Bequaert for his kind help in the compilation of the list. These parasites are recorded for the most part without any host data, and frequently where such data are given accurately the identity of the parasite is doubtful. The Hippoboscidae records are not considered in Section B.

In considering the parasites of sea-birds and of northern migratory birds, their inclusion in or omission from the list has been difficult to decide upon. Either all these records are to be included, as logically they should, or only those instances where the record is definitely from an Australian locality. The latter alternative has been taken.

Records to the following groups we omit from the listing as being too incomplete or doubtful: Froggatt (1913, *Agric. Gaz. N.S.W.*, xxiv, pp. 567–568, f. 1–5) described the larva of a bot-fly (Oestridae) attacking kangaroos. Muscoid Diptera have been recorded as parasitizing several species of birds (see Gilbert, 1919, *Emu*, xix, pp. 48–49). Bergroth (1914, *Trans. Roy. Soc. S. Aust.*, xxxviii, pp. 53–57) has described the Lygaeid bug, *Clerada nidicola*, which is recorded as possibly inquiline in the nest of *Trichosurus vulpecula* Kerr. Members of the genus *Macropocopris* (Coleoptera, Scarabaeidae) are associated with kangaroos and wallabies (see Arrow, 1920, *Ann. Mag. Nat. Hist.* (9), vi, pp. 434–437).

The joint authors take this opportunity of thanking the Trustees of the British Museum of Natural History for the facilities granted them in the Department of Entomology during the compilation of the work.

Section A.

The letters between brackets following the corrected host name refer to host-groups, as follows: Monotremata, O; Marsupialia, D; Polyprotodontia, DP; Diprotodontia, DD; Placentalia, M; Rodentia, MR; Carnivora, MCR; Pinnipedia, MP; Chiroptera, MC; Aves, A; Casuariiformes, ACA; Sphenisciformes, AS; Galliformes, AG; Columbiformes, ACO; Ralliformes, AR; Procellariiformes, APR; Lariformes, AL; Charadriiformes, ACH; Megalornithiformes, AMG; Ardeiformes, AAR; Anatiformes, AAN; Pelecaniformes, APE; Falconiformes, AF; Psittaciformes, APS; Alcediniformes, AAL; Cuculiformes, ACU; Menuriformes, AMN; Passeriformes, APA.

Note.—Such host-group abbreviations are omitted in the Nycteribiidae; all are parasites of Chiroptera.

DIPTERA.—HIPPOBOSCIDAE.

Owing to the confusion which exists in the systematics of this group, and the fact that few of the records can be taken as correct, we are listing below the species which have been recorded from Australia, together with a number of species from New Guinea and New Zealand which Dr. Bequaert considers will also be found.

1. FERONIA MACLEAYI Leach, 1818*, p. 558 (Australia). This may be an *Ornithomyia*.
2. HIPPOBOSCA AUSTRALASIAE Fabricius, 1805, p. 337, has been reported by Leach, 1818, p. 558, Pl. xxv, f. 6–8, as *Ornithomyia australasiae* from Australia, though it is doubtful if it is Fabricius' species. Tillyard (1926, p. 377, fig. W.73) records *O. australasiae* Leach from the Laughing Jackass and the Goshawk, while Cleland (1922, p. 113) doubtfully refers to this species a specimen from South Australia off *Petrochelidon ariel* (= *Lagenoplastes ariel* (Gould)). Speiser (1902, p. 329) placed *O. australasiae* F. in *Ornithoctona*.
3. LYNCHIA ACROMIALIS (Speiser), 1904, p. 386 (New Guinea).
4. LYNCHIA CHALCOLAMPRA (Speiser), 1904*a*, p. 335 (New Guinea).
5. LYNCHIA DIOXYRHINA (Speiser), 1904, pp. 387–388 (New Guinea).
6. LYNCHIA NIGRA (Perty), 1833, Delectus Animalium Articulatorum Brasiliam, iii, p. 190, Pl. xxxvii, f. 15 (Brazil). ? *Olfersia intertropica* Bau, 1929, p. 10 (N. Queensland).
7. LYNCHIA SETOSA Ferris, 1927, pp. 224–228, f. 14, 15 (Philippine Is.). Dr. Bequaert has seen this species from Queensland.
8. LYNCHIA PAPUANA (Rondani), 1878, pp. 162–163 (New Guinea).
9. LYNCHIA PARALLELIFRONS Speiser, 1902, pp. 336–337 (New Guinea).
10. LYNCHIA PLANA (Walker), 1861, p. 254 (New Guinea).
11. ? OLFERSIA SPINIFERA (Leach), 1818, p. 557, Pl. xxvi, f. 1–3. Austen (1903, p. 266) records this species from Adele Is., N.W. Australia, off *Fregata aquila* L. (= *Fregata minor* (Lesson)), but Dr. Bequaert is of the opinion that it is not true "*spinifera*".
12. ORNITHEZA METALLICA (Schiner), 1864, p. 646.—Synonym, *Ornithomyia andajensis* Rondani, 1878, pp. 155–156 (New Guinea). Dr. Bequaert has seen specimens from Queensland representing this species.
13. ORNITHOCTONA PLICATA (Olfers), 1816, De Vegetationis et Animatis corporibus in corporibus animatis reperiundis commentarius, Diss., Berlin, p. 102. Dr. Bequaert has seen specimens from Queensland.—Synonyms: *Ornithomyia batchianica* Walker, 1861, p. 300 (Batchian). ? this is *Ornithomyia batchiana* Bell. which Rondani (1878, p. 158) has recorded from N. S. Wales.—*Ornithomyia doreica* Walker, 1861, p. 254 (New Guinea).—*Ornithomyia hatamensis* Rondani, 1878, p. 158 (New Guinea).—*Ornithomyia nigricans* Leach, 1818, pp. 558–559, Pl. xxvii, f. 7–10. Recorded by Froggatt (1907, p. 321) from "white hawk", S. Queensland.—*Ornithomyia australis* Guérin, 1831, p. 302, Pl. xxi, f. 12 (Port Jackson, N. S. Wales).

* Where author and year are quoted, the journal referred to is listed in the list of references on page 126.

14. Ornithoctona ? viridipes (Walker), 1858, p. 235 (N.S. Wales). A doubtful species.

15. Ornithoica pusilla Schiner, 1868, p. 374. Dr. Bequaert has seen specimens from Queensland and N. S. Wales.

16. Ornithoica stipituri Schiner, 1868, p. 374 (*Stipiturus malachurus* (Shaw), N. S. Wales).

17. ? Ornithomyia avicularia (Linné), 1761, Fauna Suec., p. 1922. Austen (1903, p. 262) states that *Olfersia macleayi* (Walker) (1849, p. 1141) from ? New Holland is *Ornithomyia avicularia* (Linné). Austen (1906, p. 65) records "*avicularia*" from N. S. Wales and Tasmania; he also claims that in Tasmania it occurs on wallabies. Dr. Bequaert says he cannot believe that wallabies are ever the host.

18. Ornithomyia nigricornis Erichson, 1842, p. 274 (Tasmania).—Gerstaecker (1856, p. 260) claims that this is *Ornithomyia tasmanensis* Macquart (1851), while Speiser (1904*b*, p. 87) says that it is *Ornithomyia avicularia* (Linné).

19. Ornithomyia opposita Walker, 1849, p. 1145 (New Zealand).

20. Ornithomyia perfuga Speiser, 1902, pp. 331–332 (New Guinea).—Froggatt (1907, p. 321) records this species from S. Queensland off an owl (? = *Spiloglaux novaeseelandiae* (Latham)). This is "*Olfersia macleayi*" of Froggatt (1900, pp. 1090–1091, f. 3, 4 (mislabelled "*Hippobosca equina*")), which he records from wallabies, including *Halmaturus ruficollis* (= *Wallabia rufogrisea* Desmarest) and *H. perryi* (= *Wallabia elegans* Lambert). (See Austen, 1903, p. 260). Dr. Bequaert does not believe that *Ornithomyia* occurs on such hosts.

21. Ornithomyia tasmanensis Macquart, 1851, p. 309, Pl. xxviii, f. 15 (Tasmania).

22. Ornithomyia variegata Bigot, 1885, p. 245 (New Zealand).

23. Ornithophila simplex (Walker), 1861, p. 263 (Celebes). Austen (1903, p. 263) records this species from Queensland off *Tallegalla lathami* (= *Alectura lathami* Gray).

24. Ortholfersia phaneroneura Speiser, 1902*a*, pp. 153–154 (N. S. Wales).

25. Ortholfersia raveni Ferris, 1924, pp. 4–5, f. 3–4 (*Macropus* sp., N. S. Wales).

26. Ortholfersia tasmanica (Wesché), 1903, p. 385, f. 1–4 (Tasmania).—*O. tasmanica* (Wesché), Austen, 1903, p. 260 (*Macropus ruficollis* (= *Wallabia rufogrisea* Desmarest), Tasmania).—*O. tasmanica* (Wesché), Ferris, 1924, pp. 2–4, f. 1, 2 (*Macropus stigmaticus* (= *Thylogale stigmatica* Gould), N. Queensland).

Diptera.—Nycteribiidae.

Cyclopodia albertsii Rondani, 1878, pp. 150–151 (Goram); Speiser, 1901, pp. 50, 64, 71, 73.—*Nycteribia pteropus* Rainbow, 1904, pp. 78–79, Pl. ix, f. 1–14 (Gulf of Carpentaria: *Pteropus gouldi* Peters).—*C. pteropus* (Rainbow), Ferris, 1924, pp. 5–6, f. 5 (Queensland: *Pteropus conspicilatus*).—*C.* (*C.*) *pteropus* (Rainbow), Musgrave, 1925, p. 300 (N. S. Wales: *Pteropus poliocephalus* Temm.; N. Barnard Is.: *P. conspicillatus*; Queensland: unknown host).—*C. albertsi* Rondani, Scott, 1932, p. 25 (Queensland: *Pteropus gouldi*, *Pteropus* sp.).

Hosts: *Pteropus conspicillatus* Gould, *P. gouldii* Peters, *P. poliocephalus* Temminck.

NYCTERIBIA (NYCTERIBIA) BREVICAUDA Musgrave.—*N. brevicauda* Musgrave, 1925, pp. 295–298, Pl. xlv, f. 1–4 (N. S. Wales: *Nyctophilus gouldi* Tomes).

Host: *Nyctophilus timoriensis gouldi* Tomes.

NYCTERIBIA (NYCTERIBIA) BURRELLI Musgrave.—*N. burrelli* Musgrave, 1927, pp. 272–274, Pl. xxiii, f. 4, 5, 9, 12 (N. S. Wales: *Chalinolobus morio* Gray).

Host: *Chalinolobus morio* Gray.

NYCTERIBIA (NYCTERIBIA) FALCOZI Musgrave.—? *N.* (*Acrocholidia*) *oceanica* Speiser (nec Bigot), 1901, p. 41 (N. S. Wales: *Chalinolobus gouldi* Gray); 1902*a*, p. 173.—*N.* (*N.*) *falcozi* Musgrave, 1925, pp. 292–295, Pl. xliv, Pl. xlv, f. 5–7 (S. Australia: *Chalinolobus gouldi* Gray).—*N. falcozi* Musgrave, 1927, p. 265 (N.S. Wales: 'Bat'; Queensland: 'Bat'; Tasmania: *Eptesicus pumilis* Gray).

Hosts: *Chalinolobus gouldii* Gray, *Vespadelus pumilus vulturnus* Thomas.

NYCTERIBIA (NYCTERIBIA) HALEI Musgrave.—*N. halei* Musgrave, 1927, pp. 271–272, Pl. xxiii, f. 1–3, 6 (S. Australia: *Chalinolobus morio* Gray).

Host: *Chalinolobus morio* Gray.

NYCTERIBIA (NYCTERIBIA) LONGISPINOSA Musgrave.—*N. longispinosa* Musgrave, 1927, pp. 274–276, Pl. xxiii, f. 7, 8, 10, 11 (N. S. Wales: *Scoteinus rüppellii* Peters, *Scotophilus* (?) sp.). Host: *Scoteinus rüppellii* Peters.

NYCTERIBIA (NYCTERIBIA) MULTISPINOSA Musgrave.—*N. multispinosa* Musgrave, 1927, pp. 268–270, Pl. xxii, f. 5–10 (N. S. Wales: *Scoteinus rüppellii* Peters).

Host: *Scoteinus rüppellii* Peters.

NYCTERIBIA (NYCTERIBIA) TROUGHTONI Musgrave.—*N. troughtoni* Musgrave, 1927, pp. 265–268, Pl. xxii, f. 1–4 (N. S. Wales: *Chalinolobus gouldi* Gray; S. Australia: undetermined bat). Host: *Chalinolobus gouldi* Gray.

NYCTERIBIA (LISTROPODA) PARILIS Walker.—*N. parilis* Walker, 1861, p. 300; Speiser, 1901, p. 52.—*N.* (*Listropodia*) *parilis* Walker, Scott, 1914, pp. 231–234, Pl. xii, f. 20–23 (*Miniopterus australis*); *N.* (*Listropoda*) *parilis* Walker, Musgrave, 1925, pp. 298–299; Musgrave, 1927, p. 276 (N. S. Wales: *Miniopterus schreibersi* Natterer).

Hosts: *Miniopterus australis* Tomes, *Miniopterus blepotis* Temminck.

NYCTERIBIA (LISTROPODA) SARASINI Falcoz.—*N.* (*Listropodia*) *sarasini* Falcoz, 1923, pp. 89–93, f. 9–12 (Queensland: *Miniopterus australis* Tomes); *N.* (*Listropoda*) *sarasini* Falcoz, Musgrave, 1925, p. 299; Musgrave, 1927, p. 276 (Queensland: *Miniopterus schreibersi*).

Hosts: *Miniopterus australis* Tomes, *Miniopterus blepotis* Temminck.

PENICILLIDIA OCEANICA (Bigot).—*Nycteribia oceanica* Bigot, 1885, p. 246 (New Caledonia: host unknown).—*Penicillidia oceanica* (Bigot), Falcoz, 1923, pp. 86–89, f. 5–8 (New Caledonia: *Miniopterus australis* Tomes); Scott, 1932, p. 21 (Queensland: *Miniopterus schreibersi* (? *M. australis*, fide Scott), unknown host).

DIPTERA.—STREBLIDAE.

ASCODIPTERON AUSTRALIANSI Muir, 1912, p. 366, Pl. ii, f. 17*a*, *b* (N. Queensland: *Miniopterus schreibersi*). Host: *Miniopterus blepotis* Temminck (MC).

NYCTERIBOSCA AMBOINENSIS (Rondani).—*Brachytarsina amboinensis* Rondani, 1878, pp. 166–167 (Amboina: unknown host).—*N. amboinensis* (Rondani), Kessel, 1925, p. 24 (Queensland: *Miniopterus schreibersi*).

Host: *Miniopterus blepotis* Temminck (MC).

MALLOPHAGA.—BOOPIDAE.

BOOPIA BETTONGIA Le Souëf, 1902, p. 50, f. 2 (*Bettongia rufescens*).

Host: *Aepyprymnus rufescens* Gray (DD).

Boopia grandis Piaget, 1885, pp. 154–155, Pl. xvi, f. 8 (Rotterdam Zoo: *Macropus rufus*). Host: *Megaleia rufa* Desmarest (DD).

Boopia minuta Le Souëf, 1902, p. 51, f. 3 (*Macropus dorsalis*).
Host: *Wallabia dorsalis* Gray (DD).

Boopia notafusca Le Souëf, 1902, p. 50, f. 1 (*Macropus ualabatus*); Harrison and Johnston, 1916, pp. 347–348, f. 5, 6 (Victoria: *Macropus ualabatus*, *Macropus giganteus*).
Hosts: *Macropus major* Shaw (DD), *Wallabia bicolor* Desmarest (DD).

Boopia phanerocerata Harrison and Johnston, 1916, pp. 348–349, f. 7 (N. S. Wales: *Perameles nasuta*). Host: *Perameles nasuta* Geoffroy (DP).

Boopia spinosa Harrison and Johnston, 1916, pp. 350–352, f. 9 (Victoria: *Macropus ualabatus*). Host: *Wallabia bicolor* Desmarest (DD).

Boopia tarsata Piaget, 1880, pp. 599–600, Pl. l, f. 1 (plate labelled "Boopia longitarsata") (*Phascolomys fossor*); Cummings, 1916, pp. 269–271, f. 9 (*Phascolomys mitchelli* Owen).
Hosts: *Vombatus ursinus* Shaw (DD), *Vombatus hirsutus* Perry (DD).

Boopia uncinata Harrison and Johnston, 1916, pp. 349–350, f. 8 (N. S. Wales: *Dasyurus maculatus*). Host: *Dasyurops maculatus* Kerr (DP).

Dendrolagia pygidialis Mjöberg, 1919, p. 94 (Queensland: *Dendrolagus lumholtzi* Coll.). Host: *Dendrolagus lumholtzi* Collett (DD).

Heterodoxus longitarsus (Piaget).*—*Menopon longitarsus* Piaget, 1880, pp. 504–506, Pl. xli, f. 7 (Rotterdam Zoo: *Halmaturus giganteus*).—*Heterodoxus macropus* Le Souëf and Bullen, 1902, p. 159, f. 11 ('Kangaroos and Wallabies').—*H. longitarsus* (Piaget) Harrison and Johnston, 1916, pp. 353–354, f. 4, 10, 11 (N. S. Wales: *Macropus thetidis*, *M. dorsalis*, *M. rufus*, *M. giganteus*, *M. wilcoxi*, *M. robustus*; Queensland: *M. thetidis*, *M. giganteus*, *M. stigmaticus*; Victoria: *M. ualabatus*, *M. bennetti* (Zoo); Flinders Is.: *M. ruficollis*).
Hosts: *Macropus major* Shaw (DD), *Megaleia rufa* Desmarest (DD), *Osphranter robustus* Gould (DD), *Thylogale stigmatica stigmatica* Gould (DD), *Thylogale stigmatica wilcoxi* M'Coy (DD), *Thylogale thetis* Lesson (DD), *Wallabia bicolor* Desmarest (DD), *Wallabia dorsalis* Gray (DD), *Wallabia rufogrisea* Desmarest (DD).

Latumcephalum lesouëfi Harrison and Johnston, 1916, pp. 343–344, f. 2D, 3B (Victoria: *Macropus ualabatus*). Host: *Wallabia bicolor* Desmarest (DD).

Latumcephalum macropus Le Souëf, 1902, p. 51, f. 4, 4*a* ('Wallabies'); Harrison and Johnston, 1916, pp. 340–343, f. 2A, 2B, 2C, 3A (Melbourne Zoo: *Macropus dorsalis*). Host: *Wallabia dorsalis* Gray (DD).

Macropophila forcipata Mjöberg, 1919, p. 95 (*Macropus coxeni* Gray).
Host: *Thylogale coxenii* Gray (DD).

Paraheterodoxus insignis Harrison and Johnson, 1916, pp. 357–359, f. 1, 13, 14 (N. S. Wales, Queensland: *Aepyprymnus rufescens*).
Host: *Aepyprymnus rufescens* Gray (DD).

Phacogalia brevispinosus (Harrison and Johnston).—*Heterodoxus brevispinosus* Harrison and Johnston, 1916, pp. 355–356, f. 12 (Sydney Zoo: *Phascologale flavipes*).—*Phacogalia brevispinosus* (Harrison and Johnston), Mjöberg, 1919, pp. 95–96. Host: *Antechinus flavipes* Waterhouse (DP).

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* We have only included here the synonymy referring to Australian host records. The species has also been recorded from dogs in Australia, and from dogs and other animals in various parts of the world.

MALLOPHAGA.—MENOPONIDAE.

MENOPON ALBESCENS Piaget, 1880, pp. 491–492, Pl. xli, f. 4 (*Sula australis*).
Host: *Sulita serrator* (Gray) (APE).

MENOPON BIFURCATUM Piaget, 1880, pp. 423–424, Pl. xxxv, f. 10; Neumann, 1890, pp. 67–68 (*Calyptorhynchus funereus*).
Host: *Zanda funerea* (Shaw) (APS).

MENOPON COMMISSUM Neumann, 1890, pp. 66–67 (*Microglossum alecto*).
Host: *Probosciger aterrimus* (Gmelin) (APS).

MENOPON MENURA Le Souëf and Bullen, 1902, p. 158, f. 9 (*Menura superba* (Victorian form)).
Host: *Menura novaehollandiae victoriae* Gould (AMN).

MENOPON PALLIPES Piaget, 1885, p. 111, Pl. xii, f. 2 (*Excalfactoria australis*).
Host: *Excalfactoria chinensis australis* Gould (AG).

MENOPON PTEROPSITTACUS Harrison, 1916, p. 43.—*M. psittacus* Le Souëf and Bullen (nec Gurlt, 1857), 1902, p. 158, f. 8 (*Platycercus eximius*).
Host: *Platycercus eximius* (Shaw) (APS).

MENOPON PTILONORHYNCHI Ponton, 1871, p. 8, Pl. xci, f. 1 (*Ptilonorhynchus holosericeus*). Host: *Ptilonorhynchus violaceus* (Vieillot) (APA).

MENOPON SUBROTUNDUM Piaget, 1880, p. 453, Pl. xxxv, f. 2 (*Graculus sulcirostris*).
Host: *Mesocarbo ater sulcirostris* Brandt (APE).

COLPOCEPHALUM ALBIDUM Giebel, 1874, p. 268 (*Phaps chalcoptera*); Piaget, 1880, pp. 533–534, Pl. xliv, f. 5 (*Columba phasianella*).
Hosts: *Macropygia phasianella* (Temminck) (ACO), *Phaps chalcoptera* (Latham) (ACO).

COLPOCEPHALUM CASTANEUM Piaget, 1885, pp. 153–154, Pl. xvi, f. 7 (*Cygnus atratus*). Host: *Chenopis atrata* (Latham) (AAN).

COLPOCEPHALUM FLAVESCENS Nitzsch in Lyonet, 1829, p. 262, Pl. xii, f. 1; *C. flavescens* var. *major* Piaget, 1885, p. 119–120 (*Haliaëtus leucogaster*).
Host: *Cuncuma leucogaster* (Gmelin) (AF).

COLPOCEPHALUM PALLIDUM Piaget, 1880, pp. 526–527, Pl. xliii, f. 9; Neumann, 1890, p. 68 (*Cacatua barbeateri* (? = *leadbeateri*)).
Host: ? *Lophochroa leadbeateri* (Vigors) (APS).

COLPOCEPHALUM TEMPORALE Piaget, 1890, pp. 252–253, Pl. x, f. 6 (*Psittacus aterrimus*). Host: *Probosciger aterrimus* (Gmelin) (APS).

COLPOCEPHALUM TRIMACULATUM Piaget, 1880, pp. 525–526, Pl. xliii, f. 8 (*Platycercus barrabandi, P. palliceps*).
Hosts: *Platycercus adscitus palliceps* Lear (APS), *Polytelis swainsonii* (Desmarest) (APS).

COLPOCEPHALUM VINCULUM Le Souëf and Bullen, 1902, p. 158, f. 10 (*Strepera grauculina*). Host: *Strepera graculina* (J. White) (APA).

ACOLPOCEPHALUM BREVIPES Ewing, 1927, p. 88 (*Ptiloris victoriae*).
Host: *Ptiloris victoriae* Gould (APA).

ACTORNITHOPHILUS CRASSIPES (Piaget).—*Colpocephalum crassipes* Piaget, 1880, pp. 566–567, Pl. xlvii, f. 6 (*Sterna poliocerca*).
Host: *Thalasseus bergii poliocercus* (Gould) (AL).

EOMENOPON DENTICULATUS Harrison, 1915, pp. 385–388, f. 1, Pl. xxvi, f. 5, 6 (N.S. Wales: *Trichoglossus novae-hollandiae, Ptilosclera versicolor*).
Hosts: *Psitteuteles versicolor* (Lear) (APS), *Trichoglossus moluccanus* (Gmelin) (APS).

Myrsidea parumpilosa (Piaget).—*Menopon parumpilosum* Piaget, 1880, pp. 421–422, Pl. xxxiii, f. 6; Neumann, 1890, p. 68 (*Psephotus haematogaster*).
Host: *Northiella haematogaster* (Gmelin) (APS).

Myrsidea platygaster (Giebel).—*Menopon platygaster* Giebel, 1874, p. 290; Piaget, 1880, pp. 420–421, Pl. xxxiii, f. 5 (*Scythrops n. hollandiae*).
Host: *Scythrops novaehollandiae* (Latham) (ACU).

Machaerilaemus latifrons Harrison, 1915, pp. 390–392, Pl. xxvi, f. 1–4 (*Poephila gouldiae*). Host: *Gouldaeornis gouldiae* (Gould) (APA).

Tetrophthalmus australis Bedford, 1931, pp. 236–242, f. 1D, 2D, 4D, 5D, 6D (*Catoptropelecanus conspicilatus* Temm.).
Host: *Catoptropelicanus conspicillatus* (Temminck) (APE).

Trinoton nigrum Le Souëf.—*Triniton nigrum* Le Souëf, 1902, p. 90 (*Chenopis atrata*). Host: *Chenopis atrata* (Latham) (AAN).

Ancistrona vagelli (Fabricius).—*Pediculus vagelli* Fabricius, 1787, *Mant. Ins.*, p. 369.—*Ancistrona procellariae* Westwood, 1874, Thesaurus entomologicus oxoniensis, London, p. 197, Pl. xxxvii, f. 4. (*Daption capense*).—*A. gigas* Piaget, 1883, pp. 152–154, Pl. ix, f. 1.—*A. procellariae* Westwood, Harrison, 1911, pp. 633–634.
Host: *Daption capensis australis* Mathews (APR).

Trichodectidae.

Trichodectes canis (De Geer).—*Ricinus canis* De Geer, 1778, Mémoire pour servir à l'histoire des Insectes, Stockholm, vii, p. 81, Pl. iv, f. 16.—*Trichodectus ? latus*, Steel, 1919, p. 93 (N. S. Wales: *Canis dingo* Blum).—*Trichodectes canis* (De Geer), Bedford, 1932, p. 353 (Port Adelaide: 'Australian Dingo').
Host: *Canis dingo* Meyer (MCR).

Mallophaga.—Philopteridae.

Goniodes elongatus Piaget, 1880, pp. 281–282, Pl. xxiii, f. 5; Piaget, 1885, pp. 52–53, Pl. v, f. 10 (*Excalfactoria australis*).—*G. longus* Le Souëf, 1902, p. 90 (*Excalfactoria chinensis*).—*G. elongatus* Piaget, Johnston and Harrison, 1913, p. 3 (*Synoecus australis* Temm.).
Hosts: *Excalfactoria chinensis australis* Gould (AG), *Ypsilophorus ypsilophorus australis* (Latham) (AG).

Goniodes retractus Le Souëf, 1902, p. 90 (*Synoecus australis*).
Host: *Ypsilophorus ypsilophorus australis* (Latham) (AG).

Goniocotes fissus Rudow, 1869, p. 23 (*Talegallus lathami*); Taschenberg, 1882, pp. 84–85, Pl. ii, f. 7, 7*a*. Host: *Alectura lathami* Gray (AG).

Goniocotes flavus (Rudow).—*Goniodes flavus* Rudow, 1870, pp. 486–487 (*Phaps chalcoptera*).—*Goniocotes flavus* Rudow, Taschenberg, 1882, pp. 101–102, Pl. iii, f. 5, 5a. Host: *Phaps chalcoptera* (Latham) (ACO).

Goniocotes latus var. major Neumann, 1890, p. 64 (*Microglossum alecto*).
Host: *Probosciger aterrimus* (Gmelin) (APS).

Goniocotes macrocephalus Taschenberg, 1882, pp. 87–89, Pl. ii, f. 11 (*Talegallus lathami*). Host: *Alectura lathami* Gray (AG).

Lipeurus acuminatus Piaget, 1885, p. 70, Pl. vii, f. 6 (*Excalfactoria australis*).—*Oxylipeurus acuminatus* (Piaget), Mjöberg, 1910, p. 92.
Host: *Excalfactoria chinensis australis* Gould (AG).

Lipeurus crassus Rudow, 1869, pp. 31-32 (*Talegallus lathami*).
Host: *Alectura lathami* Gray (AG).

LIPEURUS ISCHNOCEPHALUS Taschenberg, 1882, pp. 173–174, Pl. vi, f. 8 (*Talegallus lathami*). Host: *Alectura lathami* Gray (AG).

AUSTROGONIODES WATERSTONI (Cummings).—*Goniocotes waterstoni* Cummings, 1914, pp. 173–176, f. 8 (Furneaux Is.: *Eudyptula minor*).
Host: *Eudyptula minor novaehollandiae* (Stephens) (AS).

PHILOPTERUS ACUTUS (Rudow).—*Docophorus acutus* Rudow, 1870, p. 463 (*Scythrops novaehollandiae*).
Host: *Scythrops novaehollandiae* (Latham) (ACU).

PHILOPTERUS ANGUSTOCLYPEATUS (Piaget).—*Docophorus angustoclypeatus* Piaget, 1880, pp. 34–35, Pl. ii, f. 3 (*Platycercus barrabandi*).
Host: *Polytelis swainsonii* (Desmarest) (APS).

PHILOPTERUS BREVIANTENNATUS (Piaget).—*Docophorus breviantennatus* Piaget, 1880, pp. 108–109, Pl. ix, f. 9 (*Sula australis*).
Host: *Sulita serrator* (Gray) (APE).

PHILOPTERUS DELPHAX (Nitzsch in Giebel).—*Docophorus delphax* Nitzsch in Giebel, 1866, p. 360 (*Dacelo giganteus*).
Host: *Dacelo novaeguineae* (Hermann) (ACL).

PHILOPTERUS EOS (Rudow).—*Docophorus eos* Rudow, 1869, p. 15 (*Cacatua eos*).
Host: *Eolophus roseicapillus* (Vieillot) (APS).

PHILOPTERUS FLAVOPUNCTATUS (Rudow).—*Docophorus flavopunctatus* Rudow, 1870, p. 458 (*Tribonyx ventralis*). Host: *Microtribonyx ventralis* Gould (AR).

PHILOPTERUS FORFICULA (Piaget).—*Docophorus forficula* Piaget, 1871, pp. 117–119, Pl. vi, f. 3 (*Platycercus barrabandi, baueri, eximius, pennanti, scapulatus*); Neumann, 1890, p. 59 (*Microglossus aterrimus*).
Hosts: *Alisterus scapularis* (Lichtenstein) (APS), *Barnardius zonarius* (Shaw) (APS), *Platycercus elegans elegans* (Gmelin) (APS), *Platycercus eximius* (Shaw) (APS), *Polytelis swainsonii* (Desmarest) (APS), *Probosciger aterrimus* (Gmelin) (APS).

PHILOPTERUS FORFICULOIDES (Piaget).—*Docophorus forficuloides* Piaget, 1880, pp. 72–74, Pl. v, f. 6; Neumann, 1890, p. 59 (*Microglossum alecto*).
Host: *Probosciger aterrimus* (Gmelin) (APS).

PHILOPTERUS GRANDICEPS (Giebel).—*Docophorus grandiceps* Giebel, 1874, p. 85 (*Ptilonorhynchus holosericeus*).
Host: *Ptilonorhynchus violaceus* (Vieillot) (APA).

PHILOPTERUS HORRIDUS (Giebel).—*Docophorus horridus* Giebel, 1876, p. 249 (*Ciconia australis*).
Host: *Xenorhynchus asiaticus australis* (Shaw) (AAR).

PHILOPTERUS LATICLYPEATUS (Piaget).—*Docophorus laticlypeatus* Piaget, 1871, pp. 116–117, Pl. vi, f. 2 (*Cuculus flabelliformis*).
Host: *Cacomantis prionurus* (Licht.) (ACU).

PHILOPTERUS LONGIPES (Rudow).—*Docophorus longipes* Rudow, 1870, p. 425 (*Ardea novaehollandiae*). Host: *Notophoyx novaehollandiae* (Latham) (AAR).

PHILOPTERUS NOVAEHOLLANDIAE (Giebel).—*Docophorus novaehollandiae* Giebel, 1874, p. 96 (*Grus novaehollandiae*).
Host: *Mathewsena rubicunda* (Perry) (AMG).

PHILOPTERUS OBCORDATUS (Piaget).—*Docophorus obcordatus* Piaget, 1871, pp. 121–123, Pl. vi, f. 6 (*Scythrops n. hollandiae*).
Host: *Scythrops novaehollandiae* (Latham) (ACU).

PHILOPTERUS PARABOLICEPS (Piaget).—*Docophorus paraboliceps* Piaget, 1890, pp. 224–225, Pl. viii, f. 2 (*'Menura lyra'*).
Host: *Menura novaehollandiae* Latham (AMN).

IBIDOECUS FLAVUS Cummings, 1916, pp. 665–669, f. 16–19 (Victoria: *Platibis flavipes* (Gould)). Host: *Platibis flavipes* (Gould) (AAR).

DEGEERIELLA BIMACULATA (Piaget).—*Nirmus bimaculatus* Piaget, 1885, pp. 148–149, Pl. xvi, f. 1 (*Barita tibicen*).

Host: *Gymnorhina tibicen* (Latham) (APA).

DEGEERIELLA BRACTEATA (Nitzsch in Giebel).—*Nirmus bracteatus* Nitzsch in Giebel, 1866, p. 369 (*Dacelo giganteus*).

Host: *Dacelo novaeguineae* (Hermann) (AAL).

DEGEERIELLA DIVERGENS (Neumann).—*Nirmus divergens* Neumann, 1890, p. 62 (*Pezoporus formosus*). Host: *Pezoporus wallicus* (Kerr) (APS).

DEGEERIELLA EOS (Giebel).—*Nirmus eos* Giebel, 1874, p. 181 (*Cacatua eos*).—*N. tenuis* Rudow, 1870, p. 471 (*Cacatua eos*).

Host: *Eolophus roseicapillus* (Vieillot) (APS).

DEGEERIELLA HECTICA (Nitzsch in Giebel).—*Nirmus hecticus* Nitzsch in Giebel, 1866, p. 366 (*Sericulus regens*).

Host: *Sericulus chrysocephalus* (Lewin) (APA).

DEGEERIELLA LIPEURIFORMIS (Rudow).—*Nirmus lipeuriformis* Rudow, 1869, p. 19 (*Scythrops novaehollandiae*).—*N. chelurus* Nitzsch in Giebel, 1874, p. 150–151.

Host: *Scythrops novaehollandiae* (Latham) (ACU).

DEGEERIELLA MENURAELYRAE (Coinde).—*Nirmus menuraelyrae* Coinde, 1859, pp. 424–425 ('*Menure-Lyre*').—*N. submarginellus* Nitzsch in Giebel, 1866, p. 368 (*Maenura superba*).—*N. menura* Le Souëf & Bullen, 1902, p. 157, f. 7.

Host: *Menura novaehollandiae* Latham (AMN).

DEGEERIELLA PARABOLICEPS (Piaget).—*Nirmus paraboliceps* Piaget, 1880, pp. 135–136, Pl. xi, f. 5 (*Psittacus aterrimus*).

Host: *Probosciger aterrimus* (Gmelin) (APS).

DEGEERIELLA PONTONI Johnston & Harrison.—*Nirmus nitzschi* Ponton (nec Giebel, 1866), 1871, p. 8, Pl. xci, f. 2 (*Ptilorhynchus holosericeus*).—*D. pontoni* Johnston & Harrison, 1913, p. 12.

Host: *Ptilonorhynchus violaceus* (Vieillot) (APA).

DEGEERIELLA SEMIANNULATA (Piaget).—*Nirmus semiannulata* Piaget, 1883, pp. 156–157, Pl. ix, f. 3 (*Barita leuconota*).

Host: *Gymnorhina hypoleuca* (Gould) (APA).

DAHLEMHORNIA ASYMMETRICA (Nitzsch in Giebel).—*Nirmus asymmetricus* Nitzsch in Giebel, 1866, p. 370 (*Dromaeus novaehollandiae*); Giebel, 1874, pp. 151–152, Pl. viii, f. 8, 9; Piaget, 1880, pp. 205–208, Pl. xvii, f. 3.—*N. setosum* Le Souëf & Bullen, 1902, p. 157.—*Dahlemhornia asymmetrica* (Nitzsch in Giebel), Keler, 1936, pp. 163–165, Pl. vii.

Host: *Dromiceius novaehollandiae* (Latham) (ACA).

PSITTACONIRMUS AUSTRALIS Harrison, 1915, pp. 403–405, f. 3, Pl. xxvi, f. 7, Pl. xxvii, f. 12–14 (N. S. Wales: *Trichoglossus novae-hollandiae*; W. Australia: *Glossopsittacus porphyrocephalus*).

Hosts: *Glossopsitta porphyrocephala whitlocki* Mathews (APS), *Trichoglossus moluccanus* (Gmelin) (APS).

RALLICOLA BISETOSA (Piaget).—*Oncophorus bisetosus* Piaget, 1880, pp. 217–218, Pl. xviii, f. 4 (*Rallina tricolor*). Host: *Tomirdus tricolor* (Gray) (AR).

RALLICOLA FALLAX (Piaget).—*Oncophorus fallax* Piaget, 1880, pp. 220–221, Pl. xviii, f. 6 (*Porphyrio melanotus*).

Host: *Porphyrio melanotus* Temminck (AR).

PARRICOLA SULCATA (Piaget).—*Oncophorus sulcatus* Piaget, 1880, pp. 218–219, Pl. xviii, f. 5 (*Parra sinensis*).
Host: *Irediparra gallinacea* (Temminck) (ACH).

PARAGONIOCOTES FASCIATUS (Piaget).—*Goniocotes fasciatus* Piaget, 1880, pp. 236–237, Pl. xix, f. 11 (*Nymphicus novaehollandiae*).
Host: *Leptolophus hollandicus* (Kerr) (APS).

ORNITHOBIUS FUSCUS Le Souëf, 1902, p. 91 (*Chenopis atrata*).
Host: *Chenopis atrata* (Latham) (AAN).

HETEROPROCTUS HILLI Harrison, 1915, pp. 394–398, Pl. xxvi, f. 8, 9, Pl. xxvii, f. 10, 11 (N. Australia: *Anseranas semipalmata*).
Host: *Anseranas semipalmata* (Latham) (AAN).

ESTHIOPTERUM CIRCUMFASCIATUM (Piaget).—*Lipeurus circumfasciatus* Piaget, 1880, pp. 301–302, Pl. xxiv, f. 6 (*Platycercus melanurus*); Taschenberg, 1882, pp. 117–118, Pl. iii, f. 13 (*Colyptorhynchus leachi*); Neumann, 1890, p. 59 (*Calyptorhynchus funereus*).
Hosts: *Calyptorhynchus magnificus* Shaw & Nodder (APS), *Polytelis anthopeplus* (Lear) (APS), *Zanda funerea* (Shaw) (APS).

ESTHIOPTERUM CAPREOLUM (Gervais).—*Philopterus capreolus* Gervais, 1847, in Walckenaer's Histoire Naturelle des Insectes, Paris, iii, Aptères, p. 253.—*Lipeurus albus* Le Souëf & Bullen, 1902, p. 157, f. 4 (*Cacatua galerita*).
Host: *Kakatoë galerita* (Latham) (APS).

ESTHIOPTERUM FORFICULOIDES (Neumann).—*Lipeurus forficuloides* Neumann, 1890, p. 65 (*Platycercus multicolor*). Host: *Psephotus varius* Clark (APS).

ESTHIOPTERUM GIGANTEUM Le Souëf & Bullen.—*Lipeurus giganteus* Le Souëf & Bullen, 1902, p. 156, f. 1 (*Antigone australasiana*).
Host: *Mathewsena rubicunda* (Perry) (AMG).

ESTHIOPTERUM GRUIS (Linné).—*Pediculus gruis* Linné, 1758, p. 613.—*Lipeurus ebraeus* Nitzsch in Burmeister, 1838, Handbuch, ii, p. 435.—*L. hebraeus* Nitzsch in Giebel, 1874, p. 226, Pl. xvi, f. 5, 6; Taschenberg, 1882, pp. 130–133, Pl. iv, f. 4 (*Grus novaehollandiae*).
Host: *Mathewsena rubicunda* (Perry) (AMG).

ESTHIOPTERUM IBIDIS Harrison.—*Lipeurus ibis* Le Souëf & Bullen, 1902, pp. 156–157, f. 2 (*Threskiornis strictipennis*).—*Esthiopterum ibidis* Harrison, 1916, p. 136.
Host: *Threskiornis molucca strictipennis* (Gould) (AAR).

ESTHIOPTERUM MENURA Le Souëf & Bullen.—*Lipeurus menura* Le Souëf & Bullen, 1902, p. 157, f. 3 (Victoria: *Menura superba*).
Host: *Menura novaehollandiae victoriae* Gould (AMN).

ESTHIOPTERUM TRABECULUM (Piaget).—*Nirmus trabeculus* Piaget, 1885, pp. 80–81, Pl. viii, f. 8; Neumann, 1890, p. 63 (*Microglossum alecto*).
Host: *Probosciger aterrimus* (Gmelin) (APS).

ESTHIOPTERUM UNGUICULATUS (Piaget).—*Lipeurus unguiculatus* Piaget, 1890, pp. 247–248, Pl. x, f. 2 (*Herodias novaehollandiae*).
Host: *Notophoyx novaehollandiae* (Latham) (AAR).

COLUMBICOLA COLUMBAE (Linné).—*Pediculus columbae* Linné, 1758, p. 614.—*Lipeurus baculus* Nitzsch, Taschenberg, 1882, p. 124 (*Carpophaga magnifica, Leucosarca plicata*).—*L. angustus* Rudow, 1869, p. 34 (*Phaps chalcoptera*).
Hosts: *Leucosarcia melanoleuca* (Latham) (ACO), *Megaloprepia magnifica* (Temminck) (ACO), *Phaps chalcoptera* (Latham) (ACO).

ANATICOLA AUSTRALIS (Rudow).—*Lipeurus australis* Rudow, 1869, pp. 38–39 (*Cereopsis novaehollandiae*).
Host: *Cereopsis novaehollandiae* Latham (AAN).

ANATICOLA CRASSICORNIS (Scopoli).—*Pediculus crassicornis* Scopoli, 1763, p. 383.—*Lipeurus squalidus* var. *major* Piaget, 1880, p. 346 (*Anas gibberiformis*).
Host: *Virago gibberifrons* (Müller) (AAN).

ANATICOLA CINEREA (Rudow).—*Lipeurus cinereus* Rudow, 1869, p. 38 (*Nyroca australis*). Host: *Nyroca australis* Eyton (AAN).

ANATICOLA MEGACERA (Johnston & Harrison).—*Lipeurus squalidus* var. *antennata* Piaget, 1880, p. 346 (*Cygnus atratus*).—*L. anatis megaceros* Johnston & Harrison, 1913, p. 6.—*Esthiopterum megacerus* (Johnston & Harrison), Harrison, 1916, p. 138. Host: *Chenopis atrata* (Latham) (AAN).

PECTINOPYGUS (PECTINOPYGUS) GYRICORNIS (Denny).—*Lipeurus gyricornis* Denny, 1842, Monographia Anoplurorum Britanniae, London, p. 167, Pl. xv, f. 1.—*L. gyricornis* Denny, Piaget, 1880, pp. 337–338, Pl. xxvii, f. 8 (*Sula australis*).
Host: *Sulita serrator* (Gray) (APE).

PECTINOPYGUS (PHILICHTHYOPHAGA) CONFUSUS (Bagnall & Hall).—*Lipeurus confusus* Bagnall & Hall, 1912, p. 9 (*Phalacrocorax sulcirostris*).
Host: *Mesocarbo sulcirostris* (Brandt) (APE).

PECTINOPYGUS (PHILICHTHYOPHAGA) SETOSUS (Piaget).—*Lipeurus setosus* Piaget, 1880, pp. 335–336, Pl. xxvii, f. 4 (*Phalacrocorax* (*Graculus*) *sulcirostris*).
Host: *Mesocarbo sulcirostris* (Brandt) (APE).

SIPHUNCULATA.—HAEMATOPINIDAE.

HOPLOPLEURA BIDENTATA (Neumann).—*Haematopinus* (*Polyplax*) *bidentatus* Neumann, 1909, p. 515 (S. Australia: *Mus rattus*). See Johnston & Harrison (1913, p. 108: '*Mus rattus*' = *Hydromys chrysogaster*), Cleland (1918, pp. 108–109).—*Hoplopleura bidentata* (Neumann), Ferris, 1921, pp. 129–131, f. 86 (N. S. Wales: *Hydromys chrysogaster*).
Host: *Hydromys chrysogaster* Geoffroy (MR).

[SIPHUNCULATA.—ECHINOPHTHIRIIDAE.

ANTARCTOPHTHIRUS LOBODONTIS Enderlein.—*A. ogmorhini* Enderlein, Neumann, 1907, p. 13 (Booth Wandel Is.: 'Phoque Crabier').—*A. lobodontis* Enderlein, 1909, p. 510, f. KK-NN (Booth Wandel Is.: *Lobodon carcinophagus* Jacquin & Puch.); Ferris, 1934, pp. 488–489, f. 284.
Host: *Lobodon carcinophaga* Hombron & Jacquinot (MP).

ANTARCTOPHTHIRUS OGMORHINI Enderlein.—*Echinophthirus setosus* Burmeister, Rothschild, 1902, p. 224 (err. det.) (*Ogmorhini leptonyx*).—*A. ogmorhini* Enderlein, 1906, p. 662, f. 1, 2 (*Ogmorhinus leptonyx*); Neumann, 1907, p. 13 (partim—Booth Wandel Is.: 'Phoque crabier'); Enderlein, 1909, p. 509 (Victoria Land: *Ogmorhinus leptonyx* de Blainv.); Ferris, 1934, pp. 486–488, f. 282, 283. Host: *Hydrurga leptonyx* Blainville (MP).]

SIPHONAPTERA.—PULICIDAE.

ECHIDNOPHAGA AMBULANS AMBULANS Olliff.—*E. ambulans* Olliff, 1886, p. 172 (N. S. Wales: *Echidna hystrix*); Rainbow, 1905, pp. 101–102, f. 25–26, Pl. xxiii, f. 1, 2; Rothschild, 1909, p. 57, Pl. ix, f. 9 (*Echidna hystrix*).—*E. ambulans ambulans* Olliff, Rothschild, 1936, p. 5, f. 2.
Host: *Tachyglossus aculeatus* Shaw & Nodder (O).

ECHIDNOPHAGA AMBULANS INEPTA Rothschild, 1936, p. 5, f. 3 (W. Australia: *Tachyglossus aculeatus ineptus* Thomas).
Host: *Tachyglossus aculeatus ineptus* Thomas (O).

ECHIDNOPHAGA ARANKA Rothschild, 1936, pp. 3–5, f. 1, 4, 5 (S. W. Australia: *Bettongia lesueuri* Quoi & Gaim.).

Host: *Bettongia lesueur* Quoy & Gaimard.

ECHIDNOPHAGA CORNUTA Wagner, 1936, pp. 332–334, f. 1 (S. Australia: *Phascolomys latifrons*). Host: *Lasiorhinus latifrons* Owen (DD).

ECHIDNOPHAGA LIOPUS Jordan & Rothschild, 1906, pp. 56–57, Pl. i, f. 2, Pl. iii, f. 20, 26 (W. Australia: *Echidna aculeata*).

Host: *Tachyglossus aculeatus* Shaw & Nodder (O).

ECHIDNOPHAGA MACRONYCHIA Jordan & Rothschild, 1906, pp. 45–47, Pl. i, f. 7, 8, Pl. ii, f. 15, Pl. iii, f. 22–24 (W. Australia: *Bettongia lesueuri*).

Host: *Bettongia lesueur* Quoy & Gaimard (DD).

ECHIDNOPHAGA MYRMECOBII Rothschild.—*Sarcopsylla myrmecobii* Waterhouse, nom. nud., 1887, p. 23 (W. Australia: *Myrmecobius*).—*Echidnophaga ambulans* Jordan & Rothschild (nec. Olliff, err. determ.), 1906, pp. 54–55 (N. S. Wales: *Trichosurus vulpecula*; Victoria: *Trichosurus vulpecula*; W. Australia: *Bettongia lesueuri, Myrmecobius fasciatus, Paragale lagotis*).—*Echidnophaga myrmecobii* Rothschild, 1909, p. 57; Ferguson, 1923, p. 90 (Franklin Is., S. Australia: *Leporillus jonesi* Thomas).

Hosts: *Bettongia lesueur* Quoy & Gaimard (DD), *Leporillus jonesi* Thomas (MR), *Macrotis lagotis* Reid (DP), *Myrmecobius fasciatus* Waterhouse (DP), *Trichosurus vulpecula* Kerr (DD).

ECHIDNOPHAGA PERILIS Jordan, 1925, p. 97, f. 3 (W. Australia: *Myrmecobius fasciatus*); Jordan, 1933, p. 66 (W. Australia: *Peragale lagotis*).

Hosts: *Macrotis lagotis* Reid (DP), *Myrmecobius fasciatus* Waterhouse (DP).

XENOPSYLLA VEXABILIS VEXABILIS Jordan.—*Xenopsylla* sp. (nr. *X. nubicus*), Ferguson, 1923, p. 90 (Franklin Is., S. Australia: *Leporillus jonesi*).—*X. vexabilis* Jordan, 1925, pp. 100–101 (Franklin Is., S. Australia: *Leporillus jonesi*).—*X. vexabilis vexabilis* Jordan, 1936, pp. 184–185.

Host: *Leporillus jonesi* Thomas (MR).

XENOPSYLLA VEXABILIS MESERIS Jordan, 1936, pp. 184–185 (Queensland: *Rattus culmorum*). Host: *Rattus culmorum* Thomas & Dollman (MR).

SIPHONAPTERA.—CERATOPHYLLIDAE.

ACANTHOPSYLLA FRANKLINENSIS Rothschild.—♂ *Acanthopsylla woodwardi* Jordan & Rothschild, 1923, pp. 304-305, f. 302, 303 (Franklin Is., S. Australia: *Conilurus albipes*).—*A. franklinensis* Rothschild, 1936, p. 9.

Host: *Conilurus albipes* Lichtenstein (MR).

ACANTHOPSYLLA PAVIDA (Rothschild).—*Pygiopsylla pavida* Rothschild, 1916, pp. 2–4, f. 1–3 (Queensland: *Petaurus breviceps, Pseudochirus lemuroides, Pseudochirus herbertensis, Dactylopsila picata, Eudromicia macrura, Pseudochirus* sp., *Dendrolagus lumholtzi*).—*A. pavida* (Rothschild), Jordan & Rothschild, 1922, p. 245 (N. S. Wales: *Pseudochirus peregrinus*; Queensland: 'Grey Scrub Rat', *Macropus thetides*).—? *A. pavida* (Rothschild), Ferris, 1924, p. 7 (N. S. Wales: *Phascologale flavipes*).

Hosts: *Dactylopsila picata* Thomas (DD), *Dendrolagus lumholtzi* Collett (DD), *Eudromicia macrura* Mjöberg (DD), *Hemibelideus lemuroides* Collett (DD), *Petaurus breviceps* Waterhouse (DD), *Pseudocheirus herbertensis* Collett (DD), *Pseudocheirus peregrinus* Boddaert (DD), *Thylogale thetis* Lesson (DD).

ACANTHOPSYLLA ROTHSCHILDI (Rainbow).—♂ *Stephanocircus dasyuri* Skuse, Rainbow, 1903, pp. 53–55 (N. S. Wales: *Dasyurus maculatus* Kerr.).—*Ceratophyllus rothschildi* Rainbow, 1905, pp. 103–107, f. 27–28.—*A. rothschildi*

(Rainbow), Jordan & Rothschild, 1922, pp. 245–247, f. 235–239. These authors recognize three geographical forms, viz.: *A. rothschildi rothschildi* (Rainbow) (p. 248, f. 235; N. S. Wales: *Dasyurus viverrinus*; Queensland: *Macropus thetides*), *A. rothschildi nereis* Jordan & Rothschild (p. 247, f. 236–238; Clerke Is., Bass Straits; *Potorous tridactylus*) and *A. rothschildi victoriana* Jordan & Rothschild (p. 248, f. 239; Victoria: *Phascologale swainsoni*).—*A. rothschildi rothschildi* (Rainbow), Jordan & Rothschild, 1923, pp. 305–306, f. 304, 305 (N. S. Wales: *Phascologale flavipes*).

Hosts: *Antechinus flavipes* Waterhouse (DP), *Antechinus swainsonii* Waterhouse (DP), *Dasyurops maculatus* Kerr (DP), *Dasyurus quoll* Zimmermann (DP), *Potorous tridactylus* Kerr (DD), *Thylogale thetis* Lesson (DD).

Acanthopsylla saphes Jordan & Rothschild, 1922, pp. 242–245, f. 232–234 (Victoria: 'Native Cat').

Acanthopsylla woodwardi (Rothschild).—*Ceratophyllus woodwardi* Rothschild, 1904, pp. 623–624, Pl. x, f. 41, Pl. xi, f. 42 (W. Australia: host unknown).—*Pygiopsylla woodwardi* (Rothschild), Rothschild, 1906, p. 221.—*A. woodwardi* (Rothschild), Jordan & Rothschild, 1922, p. 242; Rothschild, 1936, pp. 6–9, f. 7, 8 (W. Australia: *Dasyurus geoffroyi* Gould).

Host: *Dasyurinus geoffroii* Gould (DP).

Acedestia chera Jordan, 1937, pp. 313–315, f. 99, 100 (S. Australia ('Queensland' error): *Parameles gunnei*; W. Australia: *Isoodon obesulus*).

Hosts: *Isoodon obesulus* Shaw & Nodder (DP), *Perameles gunnii* Gray (DP).

Bradiopsylla echidnae (Denny).—*Pulex echidnae* Denny, 1843, pp. 315–316, Pl. xvii, f. 6 (Tasmania: *Echidna hystrix*).—*Bradiopsylla echidnae* (Denny), Jordan & Rothschild, 1922, p. 233 (N. S. Wales, Tasmania, Victoria: *Echidna hystrix, Echidna setosa*); Ferris, 1924, p. 7 (Tasmania: *Tachyglossus setosa*).

Hosts: *Tachyglossus aculeatus* Shaw & Nodder (O), *Tachyglossus setosus* Geoffroy (O).

Choristopsylla ochi (Rothschild).—*Ceratophyllus ochi* Rothschild, 1904, pp. 628–629, Pl. xi, f. 49, Pl. xii, f. 54 (Victoria: 'Opossum').—*Pygiopsylla ochi* (Rothschild), Rothschild, 1916, p. 2 (Queensland: *Trichosurus* sp. (probably *T. vulpecula*)).—*Choristopsylla ochi* (Rothschild), Jordan & Rothschild, 1922, p. 232 (N. S. Wales, Victoria: *Trichosurus vulpecula*); Ferris, 1924, p. 7 (Tasmania: *Trichosurus vulpecula*); Jordan, 1937, p. 289, f. 74 (W. Australia: *Trichosurus vulpecula*). Host: *Trichosurus vulpecula* Kerr (DD).

Choristopsylla thomasi (Rothschild).—*Ceratophyllus thomasi* Rothschild, 1904, pp. 625–626, Pl. xi, f. 46, 48 (Australia: *Acrobates pygmaea*).—*Choristopsylla thomasi* (Rothschild), Jordan & Rothschild, 1922, p. 232.

Host: *Acrobates pygmaeus* Shaw (DD).

Choristopsylla tristis (Rothschild).—*Typhlopsylla tristis* Rothschild, 1900, pp. 36–37, Pl. ii, f. 1 (Victoria: *Petaurus australis*).—*Ceratophyllus tristis* (Rothschild), Rothschild, 1904, p. 625, Pl. xi, f. 45, 47.—*Choristopsylla tristis* (Rothschild), Jordan & Rothschild, 1922, p. 233 (Victoria: *Petaurus australis, Acrobates pygmaea*).

Hosts: *Acrobates pygmaeus* Shaw (DD), *Petaurus australis* Shaw & Nodder (DD).

Glauertia scintilla Rothschild, 1936, pp. 9–13, f. 9–12 (W. Australia: *Dromicia concinna* Gould). Host: *Cercartetus concinnus* Gould (DD).

Lycopsylla novus Rothschild, 1904, pp. 602–603, Pl. vii, f. 1–4 (N. S. Wales: *Phascolomys mitchelli*); Jordan & Rothschild, 1908, p. 94.

Host: *Vombatus hirsutus* Perry (DD).

MACROPSYLLA HERCULES Rothschild, 1905, pp. 486–487, Pl. xiv, f. 9, 10 (Tasmania: *Mus velutinus*, *Mus* sp.); Ferguson, 1923, p. 91 (N. S. Wales: *Rattus assimilis*; S. Australia: *Rattus greyi*); Ferris, 1924, p. 7 (N. S. Wales: *Phascologale flavipes*).

Hosts: *Antechinus flavipes* Waterhouse (DP), *Rattus assimilis* Gould (MR), *Rattus greyii* Gray (MR), *Rattus velutinus* Thomas (MR).

PARAPSYLLUS AUSTRALIACUS Rothschild.—*P. longicornis* Jordan & Rothschild (nec Enderlein, 1901, err. determ.), 1908, pp. 85–87, Pl. ii, f. 12, Pl. iv, f. 5, Pl. vii, f. 3 (W. Australia: *Eudyptula minor*).—*P. australiacus* Rothschild, 1909, p. 62 (W. Australia: *Eudyptula minor*); Cleland, 1922, p. 113 (Flinders Is.: *Eudyptula minor*, *Puffinus brevicaudus*).

Hosts: *Eudyptula minor* (Forster) (AS), *Neonectris tenuirostris brevicaudus* (Gould) (APR).

PYGIOPSYLLA COLOSSUS Rothschild, 1906, pp. 221–222, f. 1 (Tasmania: 'Tasmanian rat').

PYGIOPSYLLA CONGRUA Jordan & Rothschild.—♂ (in part), ♀ *Ceratophyllus hilli* Rothschild, 1904, pp. 622–623, Pl. xi, f. 43 (in part), 44 (N. S. Wales: *Dasyurus viverrinus*, *Perameles nasuta*).—♀ *Ceratophyllus hilli* Rothschild, 1905*a*, p. 61 (Tasmania: *Dasyurus maculatus*).—♂ *Pygiopsylla congrua* Jordan & Rothschild, 1922, pp. 234, 236, f. 226 (N. S. Wales: *Perameles nasuta*; Tasmania: *Perameles obesula*).—♀ *Pygiopsylla hoplia* Jordan & Rothschild, 1923, pp. 236–237, f. 228 (N. S. Wales: *Perameles nasuta*; Tasmania: *Perameles obesula*, *Perameles* sp., *Ornithorhynchus anatinus*, *Dasyurus maculatus*; Victoria: 'Native Rat').—*Pygiopsylla congrua* Jordan & Rothschild, Jordan, 1937, p. 311.

Hosts: *Dasyurops maculatus* Kerr (DP), *Dasyurus quoll* Zimmermann (DP), *Isoodon obesulus* Shaw & Nodder (DP), *Ornithorhynchus anatinus* Shaw & Nodder (O), *Perameles nasuta* Geoffroy (DP).

PYGIOPSYLLA GRAVIS Rothschild, 1908, p. 620, Pl. xxx, f. 14 (Victoria: *Mus assimilis*); Jordan & Rothschild, 1922, p. 240, f. 231.

Host: *Rattus assimilis* Gould (MR).

PYGIOPSYLLA HILLI (Rothschild).—♂ *Ceratophyllus hilli* Rothschild, 1904, pp. 622–623, Pl. xi, f. 43 (in part) (W. Australia: *Bettongia penicillata*).—*P. hilli* (Rothschild), Jordan & Rothschild, 1922, p. 234, f. 225; Jordan, 1937, pp. 289–290, f. 75, 76 (W. Australia: *Bettongia penicillata*, *Pseudochirus occidentalis*).

Host: *Bettongia penicillata* Gray (DD), *Pseudocheirus occidentalis* Thomas (DD).

PYGIOPSYLLA HOPLIA Jordan & Rothschild.—♂ *Ceratophyllus hilli* Rothschild, 1905*a*, p. 61 (Tasmania: *Dasyurus maculatus*).—♂ *Pygiopsylla hoplia* Jordan & Rothschild, 1922, pp. 236–237, f. 227 (N. S. Wales: *Potorous tridactylus*, *Perameles nasuta*; Queensland: *Perameles nasuta*; Tasmania: *Perameles obesula*, *Perameles* sp., *Ornithorhynchus anatinus*, *Dasyurus maculatus*; Victoria: *Epimys assimilis*).—♀ *P. congrua* Jordan & Rothschild, 1922, pp. 234, 236, f. 229 (N. S. Wales: *Perameles nasuta*, *Potourus tridactylus*; Queensland; 'Grey Scrub Rat'; Tasmania: *Perameles obesula*).—*P. hoplia* Jordan & Rothschild, Jordan, 1937, p. 290 (Queensland: *Perameles nasuta*); Jordan, 1937, p. 311.

Hosts: *Dasyurops maculatus* Kerr (DP), *Dasyurus quoll* Zimmermann (DP), *Isoodon obesulus* Shaw & Nodder (DP), *Ornithorhynchus anatinus* Shaw & Nodder (O), *Perameles nasuta* Geoffroy (DP), *Potorous tridactylus* Kerr (DD), *Rattus assimilis* Gould (MR).

PYGIOPSYLLA RAINBOWI Rothschild, 1908, pp. 619–620, Pl. xxviii, f. 5, Pl. xxx, f. 13 (Victoria: *Mus assimilis*); Jordan & Rothschild, 1922, p. 240 (N. S. Wales: *Perameles nasuta*; Victoria: *Epimys assimilis*, *Phascologale swainsoni*).

Hosts: *Antechinus swainsonii* Waterhouse (DP), *Perameles nasuta* Geoffroy (DP), *Rattus assimilis* Gould (MR).

PYGIOPSYLLA SOLIDA Rothschild, 1916, pp. 4–6, f. 4 (Queensland: *Epimys* sp.).

PYGIOPSYLLA ZETHI (Rothschild).—*Ceratophyllus zethi* Rothschild, 1904, pp. 626–628, Pl. xi, f. 50, Pl. xii, f. 52 (Victoria: *Bettongia cuniculus*).—*Pygiopsylla zethi* (Rothschild), Jordan & Rothschild, 1922, pp. 237–238, f. 230 (N. S. Wales: *Dasyurus viverrinus*, *Perameles nasuta*; Tasmania: *Perameles obesula*).

Hosts: *Bettongia cuniculus* Ogilby (DD), *Dasyurus quoll* Zimmermann (DP), *Isoodon obesulus* Shaw & Nodder (DP), *Perameles nasuta* Geoffroy (DP).

STEPHANOCIRCUS CONCINNUS Rothschild, 1916, pp. 6–8, f. 5 (*Epimys* sp.).

STEPHANOCIRCUS DASYURI Skuse.—♀ *S. dasyuri* Skuse, 1893, pp. 78–79, Pl. xvii (N. S. Wales: *Dasyurus maculatus* Kerr.).—*S. dasyurae* Skuse, Rothschild, 1903, p. 319 (W. Australia: *Bettongia penicillata*).—*S. dasyuri* Skuse, Rainbow, 1903, pp. 53–55; Rainbow, 1905, pp. 102–103, 107–108; Rothschild, 1905*a*, p. 61, Pl. i, f. 1, 4 (Tasmania: *Mus velutinus*, *Perameles gunni*, *Dasyurus maculatus*); Jordan & Rothschild, 1911, pp. 86–87, f. 10; Rothschild, 1916, pp. 6, 9 (Queensland: *Perameles* sp., *Dasyurus viverrinus*); Jordan, 1937, p. 290 (Queensland: *Parameles nasuta*).

Hosts: *Bettongia penicillata* Gray (DD), *Dasyurops maculatus* Kerr (DP), *Dasyurus quoll* Zimmermann (DP), *Perameles gunnii* Gray (DP), *Perameles nasuta* Geoffrey (DP), *Rattus velutinus* Thomas (MR).

STEPHANOCIRCUS JARVISI Rothschild, 1908, pp. 623–624, Pl. xxix, f. 12, Pl. xxxi, f. 16 (Victoria: *Phascologale swainsoni*).

Host: *Antechinus swainsonii* Waterhouse (DP).

STEPHANOCIRCUS PECTINIPES Rothschild, 1915, pp. 25–26, Pl. ii (Victoria: *Epimys assimilis*). Host: *Rattus assimilis* Gould (MR).

STEPHANOCIRCUS SIMSONI Rothschild, 1905*a*, pp. 61–62, Pl. i, f. 2, 3 (Tasmania: *Mus velutinus*, *Dasyurus maculatus*); Jordan & Rothschild, 1911, p. 87 (Victoria: *Mus assimilis*); Ferguson, 1923, p. 91 (host of type given in error '*Dasyurus viverrinus*').

Hosts: *Dasyurops maculatus* Kerr (DP), *Rattus assimilis* Gould (MR), *Rattus velutinus* Thomas (MR).

STEPHANOPSYLLA THOMASI (Rothschild).—*Stephanocircus thomasi* Rothschild, 1903, pp. 318–319, Pl. ix, f. 4, 5 (Barrow Is., N.W. Australia: *Mus ferculinus* Thos.).—*Stephanopsylla thomasi* (Rothschild), 1911, p. 122.

Host: *Thetomys ferculinus* Thomas (MR).

STIVALIUS MOLESTUS Jordan, 1936, p. 185, f. 1, 2 (Queensland: *Rattus culmorum*); Jordan, 1937, pp. 311–312, f. 98 (Queensland: *Rattus culmorum*).

Host: *Rattus culmorum* Thomas & Dollman.

STIVALIUS RECTUS Jordan & Rothschild, 1922, pp. 257–258, f. 251, 252 (Queensland: 'Grey Scrub Rat').

UROPSYLLA TASMANICUS Rothschild, 1905, pp. 488–490, Pl. xiv, f. 11, 12 (Tasmania: *Dasyurus viverrinus*). Host: *Dasyurus quoll* Zimmermann (DP).

SIPHONAPTERA.—ISCHNOPSYLLIDAE.

ISCHNOPSYLLUS BATHYLUS Rothschild, 1936, pp. 14–15, f. 13, 14, 17 (W. Australia: *Nyctinomus australis* Gray). Host: *Austronomus australis* Gray (MC).

ISCHNOPSYLLUS CAMINAE (Rothschild).—*Ceratophyllus caminae* Rothschild, 1903, p. 323, Pl. x, f. 21, 22 (W. Australia: 'bat').—*Ischnopsyllus caminae* (Rothschild), Rothschild, 1936, p. 13, f. 15, 18 (W. Australia: *Chalinolobus morio* Gray). Host: *Chalinolobus morio* Gray (MC).

ISCHNOPSYLLUS EARINUS Rothschild, 1936, pp. 15–16, f. 16, 19 (W. Australia: *Eptesicus pumilus* Gray). Host: *Vespadelus pumilus* Gray.

ISCHNOPSYLLUS REDUCTUS (Rothschild).—*Ceratophyllus reductus* Rothschild, 1903, pp. 323–324 (Victoria: *Vespertilio macropus*).
Host: *Myotis macropus* Gould (MC).

COLEOPTERA.—STAPHYLINIDAE.

MYOTYPHLUS JANSONI (Matthews).—*Amblyopinus Jansoni* Matthews, 1878, Cist. ent., ii, pp. 278–279, Pl. vi, f. 1–7 ('Tasmaniam sub pelle Muris Ratti detectus').—*Myotyphlus jansoni* (Matthews), Fauvel, 1883, Rev. d'Ent., ii, pp. 37–40.—*Cryptommatus jansoni* (Matthews), Matthews, 1884, Cist. ent., iii, pp. 91–92, Pl. v, f. 10.

Add the following:

ANTARCTOPHTHIRUS OGMORHINI Enderlein, Harrison, 1937, p. 41 (*Ogmorhinus leptonyx* = *Hydrurga leptonyx* Blainville (MP)).

DOCOPHOROIDES HARRISONI Waterston, Harrison, 1937, p. 11 (Tasmania: *Diomedea melanophrys* = *Thalassarche melanophris impavida* Mathews (APR)). Note: Many of the bird hosts listed in this report visit the Australian coast; however, as stated in the introduction, such hosts are not listed here unless the record is for an Australian locality definitely.

MYOPHTHIRIA sp., Austen, 1926, p. 360 (Queensland). (Hippoboscidae.)

NYCTERIBOSCA MINUTA Jobling, 1934, pp. 98–99, f. 1 (Solomon Is.: *Hipposideros cervinus* Gould); Jobling, 1936, p. 178 (N. Queensland: *Rhinolophus megaphyllus* Gray = *Rhinophyllotis megaphyllus* Gray). (Nycteribiidae.)

Section B.

The letters between brackets refer to parasite groups: Diptera, D; Nycteribiidae, DN; Streblidae, DS; Mallophaga, M; Siphunculata, S; Siphonaptera, A.

AVES.

Casuariiformes.

Dromiceius novaehollandiae (Latham).
Dahlemhornia asymmetrica (Nitzsch in Giebel). (M)

Sphenisciformes.

Eudyptula minor (Forster).
Austrogoniodes waterstoni (Cummings). (M).
Parapsyllus australiacus (Rothschild). (A)

Galliformes.

Alectura lathami Gray.
Goniocotes fissus (Rudow). (M)
G. macrocephalus Taschenberg. (M)
Lipeurus crassus Rudow. (M)
L. ischnocephalus Taschenberg. (M)
Ypsilophorus ypsilophorus australis (Latham).
Goniodes elongatus Piaget. (M)
G. retractus Le Souëf. (M)
Excalfactoria chinensis australis Gould.
Goniodes elongatus Piaget. (M)
Lipeurus acuminatus Piaget. (M)
Menopon pallipes Piaget. (M)

Columbiformes.

Megaloprepia magnifica (Temminck).
Columbicola columbae (Linné). (M)
Macropygia phasianella (Temminck).
Colpocephalum albidum Giebel. (M)
Columbicola columbae (Linné). (M)
Phaps chalcoptera (Latham).
Colpocephalum albidum Giebel. (M)
Columbicola columbae (Linné). (M)
Goniocotes flavus Rudow. (M)
Leucosarcia melanoleuca (Latham).
Columbicola columbae (Linné). (M)

Ralliformes.

Tomirdus tricolor (Gray).
Rallicola bisetosa (Piaget). (M)
Porphyrio melanotus Temminck.
Rallicola fallax (Piaget). (M)

Microtribonyx ventralis Gould.
Philopterus flavopunctatus (Rudow). (M)

Procellariiformes.

Neonectris tenuirostris brevicaudus (Gould).
Parapsyllus australiacus Rothschild. (A)
Daption capensis australis Mathews.
Ancistrona vagelli (Fabricius). (M)

Lariformes.

Thalasseus bergii poliocercus (Gould).
Actornithophilus crassipes (Piaget). (M)

Charadriiformes.

Irediparra gallinacea (Temminck).
Parricola sulcata (Piaget). (M)

Megalornithiformes.

Mathewsena rubicunda (Perry).
Esthiopterum giganteum Le Souëf. (M)
E. gruis (Linné). (M)
Philopterus novaehollandiae (Giebel). (M)

Ardeiformes.

Threskiornis molucca strictipennis (Gould).
Esthiopterum ibidis Harrison. (M)
Platibis flavipes (Gould).
Ibidoecus flavus Cummings. (M)
Xenorhynchus asiaticus australis (Shaw).
Philopterus horridus (Giebel). (M)
Notophoyx novaehollandiae (Latham).
Esthiopterum unguiculatus (Piaget). (M)
Philopterus longipes (Rudow). (M)

Anatiformes.

Chenopis atrata (Latham).
Anaticola megacera (Johnston & Harrison). (M)
Colpocephalum castaneum Piaget. (M)
Ornithobius fuscus Le Souëf. (M)
Trinoton nigrum Le Souëf. (M)
Anseranas semipalmata (Latham).
Heteroproctus hilli Harrison. (M)
Cereopsis novaehollandiae Latham.
Anaticola australis (Rudow). (M)
Virago gibberifrons (Müller).
Anaticola crassicornis (Scopoli). (M)
Nyroca australis Eyton.
Anaticola cinereus (Rudow). (M)

Pelecaniformes.

Mesocarbo ater sulcirostris (Brandt).
Menopon subrotundum Piaget. (M)
Pectinopygus (*Philichthyophaga*) *confusus* (Bagnall & Hall). (M)
P. (*P.*) *setosus* (Piaget). (M)
Sulita serrator (Gray).
Menopon albescens Piaget. (M)
Pectinopygus (*Pectinopygus*) *gyricornis* (Denny). (M)
Philopterus breviantennatus (Piaget). (M)
Catoptropelicanus conspicillatus (Temminck).
Tetrophthalmus australis Bedford. (M)

Falconiformes.

Cuncuma leucogaster (Gmelin).
Colpocephalum flavescens Nitzsch in Lyonet. (M)

Psittaciformes.

Trichoglossus moluccanus (Gmelin).
Eomenopon denticulatum Harrison. (M)
Psitteuteles versicolor (Lear).
Eomenopon denticulatum Harrison. (M)
Glossopsitta porphyrocephala whitlocki Mathews.
Psittaconirmus australis Harrison. (M)
Probosciger aterrimus (Gmelin).
Colpocephalum temporale Piaget. (M)
Degeeriella paraboliceps (Piaget). (M)
Esthiopterum trabeculum (Piaget). (M)
Goniocotes latus var. *major* Neumann. (M)
Menopon commissum Neumann. (M)
Philopterus forficuloides (Piaget). (M)
Calyptorhynchus magnificus Shaw & Nodder.
Esthiopterum circumfasciatum (Piaget). (M)
Zanda funerea (Shaw).
Menopon bifurcatum Piaget. (M)
Kakatoë galerita (Latham).
Esthiopterum capreolum (Gervais). (M)
Eolophus roseicapillus (Vieillot).
Philopterus eos (Rudow). (M)
Degeeriella eos (Giebel). (M)
Leptolophus hollandicus (Kerr).
Paragoniocotes fasciatus (Piaget). (M)
Polytelis swainsonii (Desmarest).
Colpocephalum trimaculatum Piaget. (M)
Philopterus angustoclypeatus Piaget. (M)
P. forficula (Piaget). (M)
Polytelis anthopeplus (Lear).
Esthiopterum circumfasciatum (Piaget). (M)
Alisterus scapularis (Lichtenstein).
Philopterus forficula (Piaget). (M)
Platycercus elegans elegans (Gmelin).
Philopterus forficula (Piaget). (M)
Platycercus adscitus palliceps Lear.
Philopterus forficula (Piaget). (M)
Colpocephalum trimaculatum Piaget. (M)
Platycercus eximius (Shaw).
Menopon pteropsittacus Harrison. (M)
Barnardius zonarius (Shaw).
Philopterus forficula (Piaget). (M)
Northiella haematogaster (Gmelin).
Myrsidea parumpilosa (Piaget). (M)
Pezoporus wallicus (Kerr).
Degeeriella divergens (Neumann). (M)
Psephotus varius Clark.
Esthiopterum forficuloides (Neumann). (M)

Alcediniformes.

Dacelo novaeguineae (Hermann).
Degeeriella bracteata (Nitzsch in Giebel). (M)
Philopterus delphax (Nitzsch in Giebel). (M)

Cuculiformes.

Cacomantis prionurus (Lichtenstein).
Philopterus laticlypeatus (Piaget). (M)
Scythrops novaehollandiae (Latham).
Degeeriella lipeuriformis (Rudow). (M)
Philopterus acutus (Rudow). (M)
P. obcordatus (Piaget). (M)

Menuriformes.

Menura novaehollandiae Latham.
Degeeriella menuraelyrae (Coinde). (M)
Philopterus paraboliceps (Piaget). (M)
Menura novaehollandiae victoriae Gould.
Esthiopterum menura Le Souëf & Bullen. (M)
Menopon menura Le Souëf & Bullen. (M)

Passeriformes.

Gymnorhina tibicen (Latham).
Degeeriella bimaculata (Piaget). (M)
Gymnorhina hypoleuca (Gould).
Degeeriella semiannulata (Piaget). (M)
Strepera graculina (J. White).
Colpocephalum vinculum Le Souëf & Bullen. (M)
Gouldaeornis gouldiae (Gould).
Machaerilaemus latifrons Harrison. (M)
Ptiloris victoriae Gould.
Acolpocephalum brevipes Ewing. (M)
Ptilonorhynchus violaceus (Vieillot).
Degeeriella pontoni Johnston & Harrison. (M)
Menopon ptilonorhynchi Ponton. (M)
Philopterus grandiceps (Giebel). (M)
Sericulus chrysocephalus (Lewin).
Degeeriella hectica (Nitzsch in Giebel). (M)

MAMMALIA.

MONOTREMATA.

Ornithorhynchus anatinus Shaw & Nodder.
Pygiopsylla congrua Jordan & Rothschild. (A)
P. hoplia Jordan & Rothschild. (A)
Tachyglossus aculeatus Shaw & Nodder.
Bradiopsylla echidnae (Denny). (A)
Echidnophaga ambulans ambulans Olliff. (A)
E. liopus Jordan & Rothschild. (A)
Tachyglossus aculeatus ineptus Thomas.
Echidnophaga ambulans inepta Rothschild. (A)
Tachyglossus setosus Geoffroy.
Bradiopsylla echidnae (Denny). (A)

MARSUPIALIA.

Polyprotodontia.

Dasyuridae.

Antechinus flavipes Waterhouse.
Acanthopsylla rothschildi rothschildi (Rainbow). (A)
Macropsylla hercules Rothschild. (A)
Phacogalia brevispinosus (Harrison & Johnston). (M)
Antechinus swainsonii Waterhouse.
Acanthopsylla rothschildi victoriana Jordan & Rothschild. (A)
Pygiopsylla rainbowi Rothschild. (A)
Stephanocircus jarvisi Rothschild. (A)
Dasyurus quoll Zimmermann.
Acanthopsylla rothschildi rothschildi (Rainbow). (A)
Pygiopsylla congrua Jordan & Rothschild. (A)
P. hoplia Jordan & Rothschild. (A)
P. zethi (Rothschild). (A)
Stephanocircus dasyuri Skuse. (A)
Uropsylla tasmanicus Rothschild. (A)
Dasyurinus geoffroii Gould.
Acanthopsylla woodwardi Rothschild. (A)
Dasyurops maculatus Kerr.
Acanthopsylla rothschildi rothschildi (Rainbow). (A)
Boopia uncinata Harrison & Johnston. (M)
Pygiopsylla congrua Jordan & Rothschild. (A)
P. hoplia Jordan & Rothschild. (A)
Stephanocircus dasyuri Skuse. (A)
S. simsoni Rothschild. (A)

Myrmecobiidae.

Myrmecobius fasciatus Waterhouse.
Echidnophaga myrmecobii Rothschild. (A)
E. perilis Jordan. (A)

Peramelidae.

Isoodon obesulus Shaw & Nodder.
Acedestia chera Jordan. (A)
Pygiopsylla congrua Jordan & Rothschild. (A)
P. hoplia Jordan & Rothschild. (A)
P. zethi Jordan & Rothschild. (A)
Perameles nasuta Geoffroy.
Boopia phanerocerata Harrison & Johnston. (M)
Pygiopsylla congrua Jordan & Rothschild. (A)
P. hoplia Jordan & Rothschild. (A)
P. rainbowi Rothschild. (A)
P. zethi (Rothschild). (A)
Stephanocircus dasyuri Skuse. (A)
Perameles gunnii Gray.
Acedestia chera Jordan. (A)
Stephanocircus dasyuri Skuse. (A)
Macrotis lagotis Reid.
Echidnophaga myrmecobii Rothschild. (A)
E. perilis Jordan. (A)

Diprotodontia.

Phalangeridae.

Acrobates pygmaeus Shaw.
Choristopsylla thomasi (Rothschild). (A)
C. tristis (Rothschild). (A)
Cercartetus concinnus Gould.
Glauertia scintilla Rothschild. (A)

Eudromicia macrura Mjöberg.
Acanthopsylla pavida (Rothschild). (A)
Petaurus australis Shaw and Nodder.
Choristopsylla tristis (Rothschild). (A)
Petaurus breviceps Waterhouse.
Acanthopsylla pavida (Rothschild). (A)
Dactylopsila picata Thomas.
Acanthopsylla pavida (Rothschild). (A)
Pseudocheirus peregrinus Boddaert.
Acanthopsylla pavida (Rothschild). (A)
Pseudocheirus occidentalis Thomas.
Pygiopsylla hilli (Rothschild). (A)
Pseudocheirus herbertensis Collett.
Acanthopsylla pavida (Rothschild). (A)
Hemibelideus lemuroides Collett.
Acanthopsylla pavida (Rothschild). (A)
Trichosurus vulpecula Kerr.
Choristopsylla ochi (Rothschild). (A)
Echidnophaga myrmecobii Rothschild. (A)

Vombatidae.

Vombatus ursinus Shaw.
Boopia tarsata Piaget. (M)
Vombatus hirsutus Perry.
Boopia tarsata Piaget. (M)
Lycopsylla novus Rothschild. (A)
Lasiorhinus latifrons Owen.
Echidnophaga cornuta Wagner. (A)

Macropodidae.

Bettongia penicillata Gray.
Pygiopsylla hilli (Rothschild). (A)
Stephanocircus dasyuri Skuse. (A)
Bettongia lesueur Quoy & Gaimard.
Echidnophaga aranka Rothschild. (A)
E. macronychia Jordan & Rothschild. (A)
E. myrmecobii Rothschild. (A)
Bettongia cuniculus Ogilby.
Pygiopsylla zethi (Rothschild). (A)
Aepyprymnus rufescens Gray.
Boopia bettongia Le Souëf. (M)
Paraheterodoxus insignis Harrison & Johnston. (M)
Potorous tridactylus Kerr.
Acanthopsylla rothschildi nereis Jordan & Rothschild. (A)
Pygiopsylla hoplia Jordan & Rothschild. (A)
Dendrolagus lumholtzi Collett.
Acanthopsylla pavida (Rothschild). (A)
Dendrolagia pygidialis Mjöberg. (M)
Thylogale coxenii Gray.
Macropophila forcipata Mjöberg. (M)
Thylogale stigmatica Gould.
Heterodoxus longitarsus (Piaget). (M)
Thylogale thetis Lesson.
Acanthopsylla pavida (Rothschild). (A)
A. rothschildi rothschildi (Rainbow). (A)
Heterodoxus longitarsus (Piaget). (M)
Wallabia bicolor Desmarest.
Boopia notafusca Le Souëf. (M)
B. spinosa Harrison & Johnston. (M)
Heterodoxus longitarsus (Piaget). (M)
Latumcephalum lesonëfi Harrison & Johnston. (M)
Wallabia rufogrisea Desmarest.
Heterodoxus longitarsus (Piaget). (M)
Wallabia dorsalis Gray.
Boopia minuta Le Souëf. (M)
Heterodoxus longitarsus (Piaget). (M)
Latumcephalum macropus Le Souëf. (M)
Osphranter robustus Gould.
Heterodoxus longitarsus (Piaget). (M)
Megaleia rufa Desmarest.
Boopia grandis Piaget. (M)
Heterodoxus longitarsus (Piaget). (M)
Macropus major Shaw.
Boopia notafusca Le Souëf. (M)
Heterodoxus longitarsus (Piaget). (M)

Placentalia.
Rodentia.

Hydromys chrysogaster Geoffroy.
Hoplopleura bidentata (Neumann). (S)
Rattus assimilis Gould.
Macropsylla hercules Rothschild. (A)
Pygiopsylla gravis Rothschild. (A)
P. hoplia Jordan & Rothschild. (A)
P. rainbowi Rothschild. (A)
Stephanocircus pectinipes Rothschild. (A)
S. simsoni Rothschild. (A)
Rattus greyii Gray.
Macropsylla hercules Rothschild. (A)
Rattus velutinus Thomas.
Macropsylla hercules Rothschild. (A)
Stephanocircus dasyuri Skuse. (A)
S. simsoni Rothschild. (A)
Rattus culmorum Thomas & Dollman.
Stivalius molestus Jordan. (A)
Xenopsylla vexabilis meseris Jordan. (A)
Thetomys ferculinus Thomas.
Stephanopsylla thomasi (Rothschild). (A)
Leporillus jonesi Thomas.
Echidnophaga myrmecobii Rothschild. (A)
Xenopsylla vexabilis Jordan. (A)

Pinnipedia.

Lobodon carcinophaga Hombron & Jacquinot.
Antarctophthirus lobodontis Enderlein. (S)
Hydrurga leptonyx Blainville.
Antarctophthirus ogmorhini Enderlein. (S)

Carnivora.

Canis dingo Meyer.
Trichodectes canis (De Geer). (M)

Chiroptera.—Megachiroptera.

Pteropus poliocephalus Temminck.
Cyclopodia albertsii Rondani. (DN)
Pteropus gouldii Peters.
Cyclopodia albertsii Rondani. (DN)
Pteropus conspicillatus Gould.
Cyclopodia albertsii Rondani. (DN)

Chiroptera.—Microchiroptera.
Vespertilionidae.

Nyctophilus timoriensis gouldi Tomes.
Nycteribia (*Nycteribia*) *brevicauda* Musgrave. (DN)

Vespadelus pumilus Gray.
Ischnopsyllus earinus Rothschild. (A)
Nycteribia (*Nycteribia*) *falcozi* Musgrave. (DN)
Chalinolobus gouldii Gray.
Nycteribia (*Nycteribia*) *falcozi* Musgrave. (DN)
N. (*N.*) *troughtoni* Musgrave. (DN)
Chalinolobus morio Gray.
Ischnopsyllus caminae (Rothschild). (A)
Nycteribia (*Nycteribia*) *burrelli* Musgrave. (DN)
N. (*N.*) *halei* Musgrave. (DN)
Scoteinus rüppellii Peters.
Nycteribia (*Nycteribia*) *longispinosa* Musgrave. (DN)
N. (*N.*) *multispinosa* Musgrave. (DN)
Myotis macropus Gould.
Ischnopsyllus reductus (Rothschild). (A)
Miniopterus blepotis Temminck.
Ascodipteron australiansi Muir. (DS)
Nycteribia (*Listropoda*) *parilis* Walker. (DN)
N. (*L.*) *sarasini* Falcoz. (DN)
Nycteribosca amboinensis Rondani. (DS)
Miniopterus australis Tomes.
Nycteribia (*Listropoda*) *parilis* Walker. (DN)
N. (*L.*) *sarasini* Falcoz. (DN)

Molossidae.

Austronomus australis Gray.
Ischnopsyllus bathylus Rothschild. (A)

Addenda.

We are indebted to Professor Harvey Sutton, School of Public Health and Tropical Medicine, University of Sydney, for permission to publish the following records:

Isoodon torosus Ramsay. (Kuranda, Queensland).
Boopia phanerocerata Harrison & Johnston. (M.)
Pygiopsylla congrua Jordan & Rothschild. (A.)
P. hoplia Jordan & Rothschild. (A)
Rattus culmorum Thomas & Dollman. (Ingham, Queensland.)
Pygiopsylla hoplia Jordan & Rothschild. (A.)
Polyplax spinulosa (Burmeister.) (S.)

We would draw attention to the following:

Echidnophaga myrmecobii Rothschild has also been recorded from the snake, *Diemenia superciliosa*, by Jordan & Rothschild, 1906, p. 55.

'*Pygiopsylla hilli* (Rothschild)': Jordan & Rothschild, 1922, Ectoparasites, pp. 234–237, when discussing '*Pygiopsylla hilli* (Rothschild), 1904', make no reference to the record of '*Pygiopsylla hilli* (Rothschild), Rothschild, 1916, p. 6', from *Perameles macrura* (= *Isoodon torosus* Ramsay), Queensland.

The record of '*Nycteribia elongata* Rudow', 1871, *Z. Ges. Naturw.*, xxxvii, pp. 122–123, from '*Nyctophilus Geoffroyi*' has yet to be investigated: see Speiser, 1902*a*, pp. 160–161.

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A NEW SARCOCHILUS (ORCHIDACEAE) FROM THE DORRIGO.

By the Rev. H. M. R. Rupp, B.A.

(One Text-figure.)

[Read 29th June, 1938.]

Sarcochilus Harriganae, n. sp.

Planta parva cum radicibus numerosis. Folia circiter quatuor, pallida, rigida, maculata. Racemus in specimine meo cum floribus duobus, viridibus. Sepala petalaque late lanceolata, patentia. Sepalum dorsale lateralibus majus, 7 × 3 mm. Labellum cum lobis lateralibus longis, spathulatis: lobus medius cum macularum purpurearum circulo. Columna brevis.

A small plant with numerous roots, very similar to a small *S. falcatus* R.Br., but the leaves, which are pale and somewhat rigid as in that species, are beset with small dark dots. Raceme in my only flowering specimen with two flowers, having a resemblance to those of *S. olivaceus* Lindl., but of a more opaque green. Perianth segments broadly lanceolate, widening at the base. Dorsal sepal much larger than the others, about 7 × 3 mm. Lateral sepals and petals equal. Labellum with long erect spathulate lateral lobes: mid-lobe with a ring of purple spots or splashes above the blunt spur. Column short.

Sarcochilus Harriganae, n. sp.

The affinities of this little species seem to be chiefly with *S. olivaceus* Lindl. and *S. spathulatus* Rogers, and when flowers reached me without a plant, I conjectured that it might be a natural hybrid between these. The plant, however, proved to be more like *S. falcatus* R.Br., and might easily pass for that species when not in bloom, but for the dotted leaves. The flowers closely resemble those of *S. olivaceus*, but lack the golden tint of the latter, and the segments—especially the dorsal sepal—are broader. The labellum has prominent lateral lobes very similar to those of *S. spathulatus*, and just above the spur or foot of the mid-lobe is a ring of purple spots corresponding to the V-shaped or irregular marking on Dr. Rogers' species.

A small raceme was sent to me by Mr. G. E. Glissan of Balgowlah, Sydney, who had received them from Mrs. W. J. Harrigan, Deer Vale Road, Dorrigo. Subsequently Mrs. Harrigan sent me a plant, which at the time of writing (Feb., 1938) has been in my bush-house for about three months. I must admit to some doubt concerning the dots on the leaves. A new leaf which has developed on the plant just mentioned is up to the present devoid of any dots; and, although in the older leaves these do not appear to be due to piercing of the surface by an insect, it is not impossible that they may be so. Mrs. Harrigan, however, considers them characteristic of the plant. The first specimen observed was growing on a loquat tree near the homestead, but Miss M. Harrigan later found others in the forests. They were usually high up on the trees. I have named the species in honour of Mrs. Harrigan and her daughter.

ON THE TAXONOMY OF *HELICOBIA AUSTRALIS* (SARCOPHAGINAE), A DIPTEROUS INSECT ASSOCIATED WITH GRASSHOPPERS.

By A. L. Tonnoir, Council for Scientific and Industrial Research, Canberra.

(Two Text-figures.)

[Read 29th June, 1938.]

The genus *Helicobia* was erected by Coquillett (1895) to receive one species of *Sarcophaga*, *S. helicis* Townsend from North America, which has a bristly radius (first vein).

The diagnosis was as follows: "First and third veins bristly, the others bare, apical cell open, ending at three-fifths of the distance from second vein to the wing tip; bend of fourth vein rectangular and bearing a long appendage*; hind cross vein much less oblique than the apical, terminating at last third of distance between the small and the bend, its posterior end much nearer the wing-margin than to the small cross vein. Head at the vibrissae nearly as long as at insertion of the antennae, its lower margin convex; frontal bristles descending to middle of second antennal joint; sides of face each bearing a row of short macrochaetae; antennae three-fourths as long as the face, the third joint twice as long as the second; arista long, plumose on the basal three-fifths, the remainder bare; vibrissae inserted slightly above the oral margin, a few short bristles above each; cheeks as broad as the eye-height, the eyes bare. Abdomen oval, consisting of four segments, densely grey pollinose. Type: *Sarcophaga helicis* Townsend (*Psyche*, February, 1892, pp. 220–21)."

Except for the bristly R_1, all the characters enumerated in this diagnosis are too general and can hardly be taken as having any generic value.

There appear to be no further comments on this genus and no addition of species to it for about forty years; only it was recognized that the genotype *H. helicis* Towns. is a synonym of *S. rapax* Wlk.

In their work on Australian Sarcophagidae, Johnston and Tiegs (1921) described *H. australis*, but did not otherwise comment on the genus. As they had been in communication with Dr. Aldrich over their work, it is probable that the latter had pointed out to them the generic status of the fly.

Enderlein (1928) considers *Helicobia* as a synonym of *Bercea* R.-D.; but the genotype of the latter is *B. penicillata* Vill. = *haemorrhoidalis* (Fall.) R.-D. nec Fall. Hardy (1936) does not accept this generic synonymy because he thought that the genotype of *Bercea* was *S. haemorrhoidalis* Fall. However, it seems that Townsend also does not consider *Bercea* as a valid synonym; apparently he has made out that *Helicobia rapax* (Walk.) is devoid of ctenidium on the mid femora in the male and is also not so closely related to *Asceloctis* Enderlein, which this author thought might fall into synonymy with *Helicobia*, in case the genotype of this genus turned out to be devoid of the mid femoral ctenidium.

* This is probably only a fold.

In 1932 Hardy expressed his opinion on *Helicobia* in the following manner: "This generic name is a synonym of *Sarcophaga* as accepted by most authors, and I have been unable to associate the typical form with the Australian species placed under the name, although the two species have some characters in common. I retain the name *Helicobia* as being one of convenience, rather than propose a generic name at the present time because there is no unanimous opinion with regard to the limits of the associated genera." Further, he considers the presence of only three post-sutural dorsocentral bristles as typical of *Helicobia*.

In 1934 Curran (1934*a*) described *H. guianica* without discussing the genus, and in the same year (1934*b*) he described three further species from South Africa: *H. alerta*, *H. selene* and *H. monroi*. He mentions there that "the bristly R_1 is not always a generic character* in this group but that in this case it separates a fairly large group of species from the unwieldy genus *Sarcophaga* and that its use undoubtedly simplifies the identification of the species of this group".

In 1935 Townsend gave an extensive key to all the genera of the Sacophaginae but his survey does not include a detailed study of each genus. The characters he attributes to *Helicobia* in his key can be summed up as follows:

Male.	Female.
No facio-orbital bristles.	No facio-orbital bristles.
Outer vertical not developed.	Arista plumose half-way.
Frons not produced.	Two reclinate fronto-orbitals.
At least one bristle below the anterior point of frontalia.	Frontal bristles diverging, at least one bristle below the anterior point of frontalia.
Prosternum bare.	Two proclinate fronto-orbital and at least one reclinate fronto-orbital.
Three strong post sutural.	R_1 bristled to half-way.
R_1 bristled on one-third to half-way.	
Claws short.	
Tibiae not villous.	

The Australian species that Johnston and Tiegs refer to *Helicobia* differ from the above in the following way:

Male.	Female.
The facio-orbital bristles are represented by 2-5 stiff hairs.	These hairs are weaker than in the male but a few are also of a bristly nature.
Prosternum bristly.	Arista plumose to three-fifths of the way.
	Only one posterior reclinate orbital and 2 anterior proclinate.
	Frontal bristle scarcely diverging.

As it seems inadvisable to increase the number of genera of the Calliphorinae with bristly radius, *H. australis* J. & T. can reasonably be placed in *Helicobia* in spite of the discrepancies mentioned above; it could almost be placed in *Helicobiopsis* Towns., which has a bristled prosternum but is defined also by one strong facio-orbital and long claws which *H. australis* does not possess.

Helicobia australis J. & T.

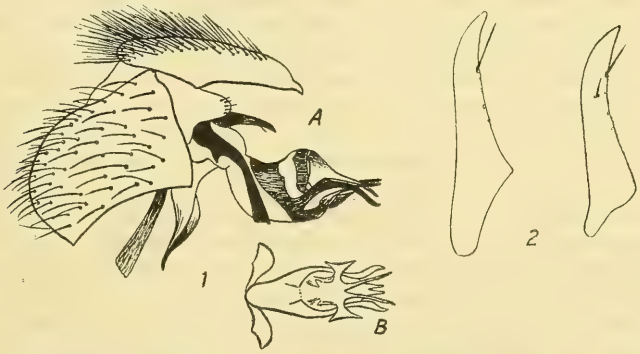
Proc. Roy. Soc. Qld., xxxiii, 1922, p. 50 and fig. 24, p. 75.

Thanks to the kindness of Mr. Longman, Director of the Queensland Museum, I was allowed to study the two male specimens from which the authors described this species.

Their description is quite accurate, but a few emendations are necessary. They may have studied the coloration of the specimens under artificial light so that it appeared on the whole too pale; thus the mesofacial plate is not pale fawn but greyish pruinose, darker than the parafacials, its ground colour more or less

* Twenty-four genera of the Sarcophaginae, 11 of Townsend, 8 of Enderlein, 1 of Aldrich, 3 of R.-Desvoidy and 1 of Coquillett, present this character of a bristly R_1.

testaceous. The second antennal segment has no silvery bloom, the third, which is only about twice as long as the second (7:4), is not silvery but greyish-brown. There are six frontal bristles on one side and 7 on the other, not 8 on both sides (this number varies from 6 to 9); it is possible that the upper vertical was counted in the row, but it can easily be distinguished from the others because it is reclinate. When the thorax is viewed from the front, the black markings of the notum appear very shiny; the lateral black vittae do not extend on the scutellum but its corners are narrowly black. The median dark vitta extends on the disc of the scutellum but does not reach its tip. There are no distinct anterior acrostichals, no post-humeral (the two mentioned by Johnston and Tiegs must be the anterior presupraalar and preintraalar)*, there are three intraalar (posterior) and not two. The chaetotaxy of the thorax is therefore as follows: 1 pair of prescutellar acrostichal, 2 predorsocentral, 3 postdorsocentral, 1 preintraalar, 3 postintraalar, 3 humeral, 2 presupraalar, 3 postsupraalar, 2 to 4 notopleural, 2 postalar, 2 lateral scutellar, 1 pair apical scutellar cruciate, and one pair discal scutellar bristles.



Text-figs. 1-2.—*Helicobia australis*. 1A, Male hypopygium, × 33; 1B, Phallus, ventral view, × 33; 2, Posterior claspers, × 100.

The hypopygium of the holotype has been figured by Johnston and Tiegs (fig. 24), but as it had not been treated with potash the phallus was not extended and the figure does not give an exact idea of its complicated structure. This organ was removed by me from the holotype and treated with potash and was then drawn by means of the camera lucida in liquid medium so that no pressure was exerted upon it (see fig. 1A). The posterior clasper carries only one bristle, there is no trace whatsoever of a second one or of a pore where a second one might have been inserted. The posterior claspers of at least half-a-dozen other specimens have been examined and in only one of them was there a second very small lateral bristle found on one of the claspers only (fig. 2). I am quite satisfied that this species lacks the second bristle of the posterior claspers which Hardy considers as a special character of *Helicobia* and of a group of species of *Sarcophaga*. The complicated phallus is characterized by four pairs of projections as can be seen in the ventral view of that organ (fig. 1B); the two long and thin ventral ones being serrated on their internal edge. The hypopygium of *Helicobia monroi* Curran from South Africa, which I have studied, has a similar phallus; the homologous ventral projections have also a serrated edge. In this species the posterior clasper also carries only a single bristle.

* Terminology of Townsend.

The holotype and the paratype are rather teneral and undersized; they were bred specimens and may have been underfed and killed too soon after emergence. All specimens obtained by me under natural conditions are about 7 mm. long instead of 5 and their bristles are much stronger.

As the female has not yet been described I give here the description of a specimen which I have chosen as the allotype. It is deposited in the collection of the Division of Economic Entomology at Canberra.

Head: frons wide, somewhat more than one-third of the head-width (15:19); parafrontalia darkish testaceous pruinose above, paler below, the parafacials almost silvery in certain light; interfrontalia velvety blackish-brown; antennae dark brown, the third segment very slightly pruinose, palpi and proboscis dark brown; mesofacial plate and peristome slightly testaceous. Second antennal segment not as long as the third (6:10), arista plumosity equal on both sides, arista thick on its basal quarter, very thin distally. Chaetotaxy: 7 frontal bristles on each side, 3 orbital, the two anterior ones proclinate, the last one reclinate, 2 proclinate ocellar (plus a pair of very thin hair-like bristles curved outwards), internal and external verticals present, one pair of small postocellar bristles. About four small bristles on the parafacials along the eye-margin, vibrissae long and cruciate, three small bristles above them on facial ridge. Eyes bare.

Thorax dull, slightly testaceous grey, with three almost mat dark lines, the median one extending distinctly on the scutellum, the disc of which is therefore all black and the sides grey. On the sides, the meso-pleurae are more distinctly testaceous grey than the rest. Chaetotaxy: no distinct anterior acrostichal, only one pair of them antescutellar and small, 5 large dorsocentral and a small anterior one, 3 humeral, 1 large preintraalar, 3 postalar, 2 lateral scutellar, 2 discal (almost preapical) scutellar, one propleural, one mesopleural spiracular, 6 mesopleural, 3 sternopleural in line and 3 pteropleural bristles. *Wings* as in most Sarcophaginae, but R_1 bristled, cell 5r open, ending well before the wing tip, no M_2 stump, *m* wavy, *r-m* oblique, one costal spine. *Legs* as in male, no ciliae on hind tibiae. *Abdomen* moderately shining, marmorated with dull grey, chaetotaxy as in male, that is: one lateral marginal on segments II and III, 3 lateral on segment IV and one pair of dorsal marginal, 6 large marginal on segment V.

Length, 7 mm., wing 5·5 mm. (smallest female 5 mm.).

Black Mountain, Canberra, F.C.T., mid March, 1936, bred in cages containing *Austroicetes pusilla* from local origin.

Among the numerous other females of the same lot were some specimens with only 6 frontal bristles and one with a single apical scutellar bristle.

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ON THE BIOLOGY AND EARLY STAGES OF *HELICOBIA AUSTRALIS* (SARCOPHAGINAE), A DIPTEROUS INSECT ASSOCIATED WITH GRASSHOPPERS.

By Mary E. Fuller, B.Sc., Council for Scientific and Industrial Research, Canberra.

(Five Text-figures.)

[Read 29th June, 1938.]

Most of the following observations were made on *Helicobia* bred in culture in the laboratory, the original flies having been obtained from Mr. A. L. Tonnoir's grasshopper field-cages. These comprised five females and two males which emerged between 4th and 6th November, 1936, from cages containing *Austroicetes pusilla*. At the end of April, 1937, they had reached the seventh generation, and numbered many thousands. The first generation was bred in a small field-cage, the flies being provided with dates, water and liver. During December it was found that they could develop normally and more rapidly in the laboratory, so the culture was moved indoors.

The flies were active, flying rapidly about the cage, and feeding freely from the dates and sugar provided. They mated frequently, from the first day of emergence and at any time of the day. The females deposited their larvae on the liver, and the larvae were reared on meat through each generation.

Life Cycle, Longevity and Fecundity.

The shortest period between the emergence of the female and the first deposition of larvae was six days. The feeding period of the larva was three to four days, and the pupal period usually ten days. In the small laboratory cages, during the three summer months (maximum temperature ranging from 68 to 87°F.), the period from adult to adult was twenty-three days. The average length of the life cycle for the seven generations reared was thirty days.

A pair of flies of the third generation was isolated in a small cage. Six days after emergence the first batch of maggots was deposited, and five other batches were subsequently produced. Counting only flies or puparia, without considering mortality amongst the larvae, the total progeny was 133, giving an average of 22 maggots to each batch. The first three batches were much larger than the later ones. Before the last batch of maggots was deposited, flies had emerged from the first batch and produced larvae. Of the relatively few larvae deposited in each batch, a proportion usually succumbs, either from desiccation after hatching or from failure to escape from the membranous chorion. Two females were dissected, one six days and one seven days after emergence. The first contained a few maggots and many well developed embryos, and the second contained sixty-seven maggots.

From the beginning of autumn onwards a large proportion of puparia failed to produce flies, whereas previously practically one hundred per cent. had done so. Dissection showed healthy nymphs but little developed. At this stage cages

were transferred to a constant temperature room (22°C.), where development continued without interruption until early in May. The puparia of the last generation formed in middle May remained in that stage for three to four months, indicating that hibernation is coincident with a diapause. Since larvae pupate readily, whether at high or low temperatures, it is obvious that *Helicobia* passes the winter in the pupal stage, not, as in many Calliphorinae, as a prepupa.

Early in April the Chalcid, *Mormoniella vitripennis*, entered one of the cages of sixth generation flies and a large proportion of the puparia were parasitized.

Larviposition Preferences and Larval Food.

The female prefers moist under-surfaces, holes or crevices in the medium for larviposition, and meat in a decomposed state is preferred to fresh meat. When the flies were offered the choice of meat and dead grasshoppers (including *Chortoicetes terminifera*, *Austroicetes pusilla*, *Gastrimargus musicus* and *Phaulacridium vittatum*), they showed a decided preference for the meat. After three hours maggots were present on the meat and none on the hoppers. After one day the meat was full of maggots and only one hopper had two maggots on it. The flies prefer a fresh mouse carcase to freshly-killed grasshoppers, the maggots being placed in the mouth and eyes in the same manner as *Calliphora augur*. When dead grasshoppers only were provided, several maggots were deposited on each, being placed in any position, but most frequently under the base of the hind leg. Some of the dead hoppers had a number of small shrivelled maggots attached to them, and one large living maggot inside. Meat or dead grasshoppers were preferred to live grasshoppers, in which the flies never showed any interest. Live hoppers of various species, including those listed above, and in all stages of development, were provided both in field and laboratory cages. They were removed at frequent intervals, examined and dissected, but none contained *Helicobia* larvae. When meat was provided in these cages larvae were deposited on it, when no meat was provided the larvae were deposited on dead grasshoppers, and when hoppers were removed as soon as dead, no larvae were produced.

Larval Food:

1.—A freshly-killed large grasshopper and small mouse of approximately the same size were each split and six *Helicobia* placed in each. Two days later only one maggot was alive in the grasshopper and was found inside the head. There were four large maggots in the mouse. All five larvae pupated. A skinned mouse put into a cage of flies had many maggots deposited on it, and these grew rapidly to a large size. It is interesting to note that the flies bred in the cultures on meat are generally larger than wild flies, which apparently breed in dead grasshoppers only.

2.—One *Helicobia* larva was put under the base of the hind leg of each of three dead grasshoppers. Only one of these larvae survived.

3.—One *Helicobia* larva was placed on each of six immature live grasshoppers, either under the scutellum, base of the hind leg, or on the spiracle. Two days later three of the hoppers were killed and dissected, but revealed no trace of the larvae. The other three were kept for some weeks and allowed to grow, and then killed and dissected, but no maggots were found. It thus appears that, not only will the female flies refuse to larviposit on live grasshoppers, but larvae are unable to develop on them.

4.—It was observed many times that larvae of the same age on meat and on dead hoppers were different in size. Unless the hoppers dried up rapidly the

feeding stage was of the same duration in both, but fully-fed larvae on hoppers were never as large as those on meat.

5.—The only instance in which *Helicobia* larvae were found in the field was when the bait pan of a trap, set for four days with dead hoppers and water, contained *Helicobia* and *Calliphora augur* maggots.

Sheep Strike: Newly-deposited larvae were placed on a sheep in the insectary, the wool being moistened. On examining the sheep 18 hours later a typical strike was found to have developed. Forty-nine hours after being placed on the sheep the maggots were full-fed and exceptionally large, and had produced a brown, irritated patch on the skin 2 inches long by 1 inch wide, although they were scattered in the wool all round. The maggots were removed, allowed to pupate, and all produced flies.

Helicobia in Blowfly Traps.

It was observed during general blowfly trapping that a few *Helicobia* were frequently caught in carrion-baited traps. The following experiments were then carried out to find if it is attracted to specific baits.

1.—A glass trap was set in the field, using dead grasshoppers as bait. After four days thirteen *Helicobia*, comprising 7% of the total flies, were caught.

2.—Two traps were set for four days.—*A*, baited with dead hoppers, caught 27 *Helicobia*, equalling 45% of the total catch; *B*, baited with a dead rat, caught 3 *Helicobia*, equalling 2% of the total.

3.—Three traps were set for two days.—*A*, baited with dead hoppers, caught 5 *Helicobia* = 35%; *B*, baited with a dead rat, caught 4 *Helicobia* = 3%; *C*, baited with dead snails, caught 4 *Helicobia* = 2%.

These experiments were carried out in February. During February and March a few *Helicobia* were caught in most of the glass traps set for other purposes. They were attracted to liver, small carcases, snails and worms, whether untreated or sprinkled with borax. At the end of March they were also caught in large Western Australian traps baited with liver.

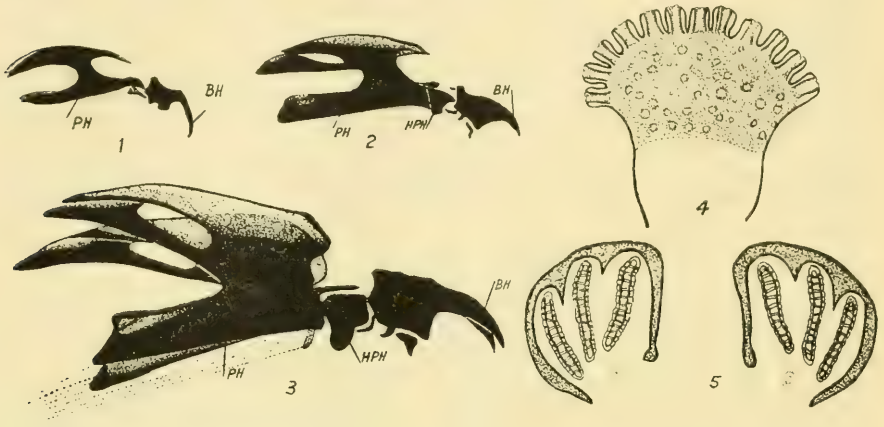
First Stage Larva.

Larvae taken from the ovaries of the female, or as they are deposited, measure from 2 to 2½ mm. in length. They are white and semi-transparent, showing the bucco-pharyngeal armature extending the length of the thoracic segments. The two head-lobes are distinct, each with antenna and maxillary palp. The antenna consists of a small round swelling with a short finger-like segment in the centre. The maxillary palp is a flat disc with a number of minute sensillae arising from it.

The larva is a typical maggot shape, with each segment bounded by an annulation made of several rows of tiny setae. The setae are most strongly developed ventrally where they appear as broad-based spines, and become weaker dorsally, appearing as fine hairs. They are directed backwards, except on the dorsum, where they point forwards. The fifth, sixth and seventh segments have the dorsal setae most strongly developed. The spines are almost colourless to light brown in colour. The first thoracic segment has the anterior border particularly heavily spined ventrally, the spines being strong and almost black and directed forwards. The posterior spiracles are situated at the bottom of the typical Sarcophagid spiracular hollow on the eighth abdominal segment. The lobes of the invagination are fringed with fine setae. The tracheal trunks end in a felt chamber and a pair of slits, these being visible through the skin dorsally.

The bucco-pharyngeal armature (Text-fig. 1) consists of a basal pharyngeal sclerite and the pair of oral hooks. The dorsal thecal arch of the pharyngeal

sclerite projects forwards into a long point. The buccal hooks are slender, sharply pointed, and unusually long in comparison with the length of the pharyngeal sclerite.



Text-figs. 1-5.—*Helicobia australis*.—Buccopharyngeal armature of larva. 1, First stage; 2, Second stage; 3, Third stage, × 65—*bh*, buccal hooks, *ph*, pharyngeal sclerite, *hph*, hypopharyngeal sclerite; 4, Anterior spiracle, × 170; 5, Posterior spiracles, × 100.

Second Stage Larva.

In this stage the larva is 3½ to 6 mm. long. It is white and opaque, although the bucco-pharyngeal armature may still be discerned through the thorax. The dorsal surface has the segmental bands spread out widely over the surface, so that a large part is spinose, but the spines are minute, flat and light coloured, being less conspicuous than in the first instar. The spines have a broad scale-like base with a very short point. They are most developed on the ventral surface. As in the first stage, there is a ventral arch of strong spines at the fore-border of the first thoracic segment. The head and antenna are similar in structure to the first stage. The spiracular hollow is dorsal, deep and with a wide oval aperture. The margin is marked by several rows of minute brown spines. The spiracles have two slits in each plate, the slits having the characteristic slope of Sarcophagids. The anterior spiracles are similar to those in the third-stage larva, and have the same number of processes. On each side of the anus is a large papilla projecting laterally, these being posterior to the spiracular hollow. The bucco-pharyngeal armature (Text-fig. 2) has, in addition to the pharyngeal sclerite and buccal hooks of the first instar, a hypopharyngeal sclerite connecting the two. The hooks are shorter and broader and a pair of small dental sclerites are present near their base.

Third Stage Larva.

The length is from 6½ to 13 mm., those measuring 12 or 13 mm. being full-grown. Some maggots were found to be in the third instar two days after deposition in January, so the earlier instars are very brief in summer. The larva is of a typical maggot form, with a pointed anterior and truncated posterior end. It is white, with the segmentation very indistinct owing to the small spines usually confined to segmental annuli being spread over the whole surface. The bilobed head is similar to that in the second stage larva, but the antenna and palp are

slightly chitinized, appearing as yellow dots. The antenna has a short cylindrical segment and a small finger-like apical segment. The oral grooves are well-developed in this instar.

Each thoracic segment has a wide band, consisting of about 12 rows of spines, at the fore-border. The rest of the segment is smooth, except for the presence of a few spines dorsally on the third. The first segment is unusually short. The abdominal segments, with the exception of a few small areas, are covered with small flat colourless scales with minute spines pointing backwards. In the posterior fourth, scales point forwards from third to seventh segments of abdomen. The centre of each segment is smooth ventrally, except the eighth, and there is a narrow intersegmental membrane which is without scales. Ventrally each segment has a pair of large rounded swellings on each side of the mid-line. On the smooth ventral area between the swellings and in the centre of each abdominal segment in a transverse series are six small slightly raised oval tubercles with invaginated centres. Laterally there are one or two, and dorsally eight to ten, of these small mounds, but the dorsal and lateral ones are not as prominent as the ventral. They are devoid of spines.

On the eighth segment the only smooth areas are a small patch between the spiracular hollow and the anus, the extreme tip of the anal papillae, a narrow strip below the anus, and the inside of the spiracular hollow. There are three pairs of small papillae both on the upper and lower margins of this hollow which is a wide oval in shape. Around its margin the small spines of the integument are particularly dense and acutely pointed. The anus is prominent, with a pair of large lateral papillae, which are spiny except at the tip.

The anterior spiracles (Text-fig. 4) project prominently from the dorso-lateral surface of the first thoracic segment near the posterior margin. They are orange-coloured and bear twelve to fourteen processes. The posterior spiracles (Text-fig. 5) lie in the deep invagination of the eighth abdominal segment and are also orange-coloured. The plates are separated by about half the spiracular width. They have the typical Sarcophagid form, with a gap in the peritreme near the button and the slits sloping in the characteristic fashion.

The bucco-pharyngeal armature (Text-fig. 3) consists of the pharyngeal sclerite, with divided dorsal cornu of Sarcophagid, the hypopharyngeal sclerite and the buccal hooks, with the small dental sclerites and hypopharyngeal plates. The structure of these component parts is very characteristic for all Calliphoridae examined and illustrated by other workers. The armature in *Helicobia* is of the usual type, without any distinctive or unusual features, and almost identical with those illustrated for species of *Sarcophaga*. The interesting feature lies in the fact that the pharynx is definitely ridged, indicating that the larva is saprophagous rather than parasitic (Keilin, 1924).

The Puparium.

The puparium from a well-grown larva measures 7 to 8 mm. in length and 3 to 4 mm. at its greatest width. The colour changes from a bright reddish-brown to dark brown with age. It is rotund and convex all round, with the appearance of a small *Sarcophaga* puparium. At the posterior end is the usual deep concavity of all *Sarcophaga* puparia. The surface shows the spines of the third-stage larva flattened and blunted. The anterior spiracles of the larva project out in front of the puparium at the anterior end. There is no trace of external breathing horns. The pupa has a pair of spiracles on the thorax, but apparently these never break through the shell of the puparium.

Discussion.

Noble (1936) bred *Helicobia australis* from grasshoppers collected at Burren Junction, and recorded it as a parasite. It has also been found occasionally in the grasshopper cages at Canberra, but there is no evidence that it developed in living hoppers. The observations recorded in this paper show that this species is not a parasite, but develops normally in dead hoppers. It probably breeds also in other dead insects, in the same manner as species of *Sarcophaga*, and possibly also in the carcases of small native mammals. Cuthbertson (1935) records *H. monroi* Curran from Rhodesia breeding in faeces and bodies of dead locusts.

The larva of no species of *Helicobia* has been previously described. Although it is closely related to *Sarcophaga*, the mouth parts and spiracles being similar in both, there are definite features which distinguish *Helicobia* from any other Sarcophagid. The integumental spines in all *Sarcophaga* larvae, including *S. depressa* bred from dead grasshoppers, are more or less limited to the segmental bands and the prominences, but *Helicobia* is almost uniformly spinose. Also, *Helicobia* has a thinner integument than is usual in *Sarcophaga*, and has the ventral and lateral protuberances less developed. The most spinose species of *Sarcophaga* larva described is that of *S. cistudinis* Ald. (Knipling, 1937), a parasite of tortoises. *Helicobia*, however, is more completely spinose than this species, and is also distinguished from it by the prominent tubercles on the eighth abdominal segment, these being greatly reduced in *S. cistudinis*.

The puparia of *Helicobia* and *Sarcophaga* are very similar, except in size. Cuthbertson described the puparium of *H. monroi*. In general shape and size it resembles that of *H. australis*. Specimens which Mr. Cuthbertson kindly forwarded were dissected and some knowledge of the larva thus gained. Evidently *H. monroi* has the integumental spines confined to the segmental bands as in *Sarcophaga*. It differs also from *H. australis* in having short inconspicuous anterior spiracles with only six processes. The posterior end with its spiracular cavity and tubercles is similar in both, as is also the bucco-pharyngeal armature, except that the oral hooks are shorter and broader in *H. monroi*. There is, however, no reason in the early stages to warrant separating them generically.

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THE ECOLOGY OF THE UPPER WILLIAMS RIVER AND BARRINGTON TOPS DISTRICTS. II.

THE RAIN-FOREST FORMATIONS.

By Lilian Fraser, D.Sc., and Joyce W. Vickery, M.Sc.

(Plates vii–xiii.)

[Read 29th June, 1938.]

The Sub-Tropical Rain-Forest: Method of Study; Distribution; Composition; Structure; The Rain-Forest Margin; Outliers; Regeneration; Special Features; Allied Rain-Forest Areas; Rain-Forest Outliers to the east and west of the Plateau.

The Sub-Antarctic Rain-Forest (Beech Forest): Distribution; Composition; Structure; The Margins of the Sub-antarctic Rain-Forest.

Discussion and Conclusions: Distribution; Structure; Composition and Comparison with other Rain-Forest Areas in N.S.W.; Ecological Relationships; Distribution of Species.

The Sub-Tropical Rain-Forest.

Method of Study.

(*a*) *Composition.*—Before any comprehensive work could be done on the structure of the rain-forest or the distribution of species within it, it was necessary to become familiar with the habit, leaves and bark of the commonly-occurring species, so that all except a small fraction could be identified in the field at once.

(*b*) *Structure.*—The difficulty of study in a sub-tropical rain-forest is due to its vertical extent and density, and the very large number of species of trees present. Since one can see a short distance only within the forest and many of the component trees have a very similar appearance, the observer cannot at once gain from a general survey any idea of the distribution of species in it. At first sight it appears relatively homogeneous, the trees being more or less evenly distributed, the chief differences apparently being due to variations in the ground flora. A preliminary survey was made along routes chosen at random through areas of forest growing under uniform conditions. The results indicated at once that the individual species were not evenly distributed. The following method of sampling was therefore adopted to demonstrate this variation in structure: An area of rain-forest, one to several acres in extent, was chosen at random with the same general habitat and showing no observable differences due to special causes. Within this area 10–25 circular plots of 10 feet radius were chosen, again at random. Within each plot all large plants were counted, and their heights and diameters recorded. When ferns were present in the ground stratum they were indicated as numerous, scanty, or rare. By this method it was possible to obtain an idea of the relative abundance and importance of any species in any one area, and, by comparing records from different localities, to arrive at a conclusion as to the distribution and density of any one species and the relation of species to specialized habitats, such as river banks. Both sub-tropical and sub-antarctic rain-forests were analysed in this way. Once the general features had thus been determined in a part of the forest, it was found possible to supplement the

knowledge thus gained by direct observations over larger areas, in the light of these conclusions.

The structure of rain-forest margins, and river and creek floras, was noted from time to time wherever changes were apparent, and relevant data regarding aspect were recorded.

The heights of trees were calculated by means of an Abney level where possible. Elsewhere they were estimated by comparison with the more or less standard layers of the canopy.

(*c*) *Distribution.*—It was not possible to map in detail the boundaries of the Williams and Allyn River rain-forests, but it was necessary to define the factors which determined the extent of the rain-forest in special areas. Consequently the altitudes of the margins of the formation were recorded and compared in cases which illustrated the influence of certain factors, e.g., on either bank of the main river, either side of the Williams–Allyn Divide, and up the sides of creeks.

Distribution.

The margin of the rain-forest is very well defined and no difficulty is found in tracing its boundaries. These are shown approximately in Map 1, Part 1 (These Proc., 1937, p. 272). On the north-east side of the Williams Range the rain-forest extends 500 to 600 feet higher than on the south-west side. In the sheltered beds of creeks, however, the rain-forest on the south-western side approaches that on the north-east side. In several places where a depression in the ridge marks the heads of two creeks, one on either side of the range, the outlier species of the rain-forest on both sides of the ridge form a common community, and in time the forest will extend completely over the ridge, especially if a high part of the range to the west provides some degree of shelter and an accumulation of soakage.

In the lower part of the Williams River valley, at the lower limit of the rain-forest, the margin on the east-facing side of the valley is 200 feet below that on the west-facing side. This is probably due to the fact that on the western side the valley is more flat than on the eastern, so that the eastern side is damper, due to soakage, and this factor appears to be of more importance in the distribution of rain-forest species than does the slightly greater amount of shelter obtaining on the western side.

Composition.

A list of all Angiosperm and Fern species which have been found in the sub-tropical rain-forest is given in Table 1. It is probably incomplete, but any species not included must be of rare occurrence. The flora of the rain-forest includes trees, lianes, shrubs, epiphytes, and herbaceous plants. A large number of families is represented, but the number of species belonging to each is small. It can be seen that the number of species belonging to the Pteridophytes is large (35); next in abundance are the orchids (15), species of the Myrtaceae (12), and Lauraceae (9).

Structure.

(*a*) *Stratification.*

The sub-tropical rain-forest is predominantly a tree formation, and the tree strata are the most conspicuous and continuous. Stratification of the component species of the rain-forest, the importance of which has been much emphasized by workers in tropical rain-forests elsewhere, does not appear at first sight to be strongly marked in the Williams River rain-forest. This is due to the discontinuous nature of the lower strata and to the occurrence of large numbers of tree

seedlings and saplings showing a complete range of height from a few inches to maturity. The following strata, however, can be distinguished.

In the mature rain-forest the main tree-stratum has a height of 60–80 feet, occasionally 100 feet (Pl. vii, fig. 1). It is not, however, a level attained by all trees equally. Well-grown trees of *Ficus Henneana*, *Dysoxylum Fraseranum*, *Diploglottis Cunninghamii* and others frequently stand out well above the general level, so that the upper level of the canopy is most uneven. The members of this stratum characteristically have laurel-like leaves. Drip tips are common and pulvini almost universal. All species except *Cedrela australis*, *Ehretia acuminata*, and *Ficus Henneana* (Meliaceae, Boraginaceae and Moraceae respectively) are evergreen. The lower level of the canopy is high above the ground, few leaves being produced from the lower parts of the trunks. The actual canopy, therefore, though very dense, may not be very deep (20–40 feet).

Until their foliage reaches the level of the canopy the trunks of young trees are very thin and the spread of their canopy is small. Often a young tree 40 feet high may have, at three feet from the ground, a diameter of only 3 inches (Pl. vii, fig. 1; xiii, figs. 54, 55). Practically every tree carries a heavy load of epiphytes (Pl. xiii, figs. 56, 58). These are especially abundant on the taller trees which extend slightly above the general level of the canopy and whose branches in consequence probably receive more light than below the canopy. Lianes are also numerous (Pl. vii, fig. 1; viii, figs. 15, 16; xiii, fig. 56) and bind the tree tops together, thus considerably increasing the density of the canopy (Pl. viii, figs. 13, 14). The stems of the lianes often form tangled masses on the forest floor (Pl. xiii, fig. 53).

The canopy of the tree layer causes a very great decrease in the light intensity below it (Pl. vii, fig. 1). It allows through a subdued light only and small flecks of sunlight.

In many places above the canopy of the tallest rain-forest trees rise the trunks of trees belonging to a discontinuous uppermost stratum (Pl. vii, figs. 3, 4; viii, fig. 12). These trees belong to the species *Eucalyptus saligna* and *Syncarpia laurifolia*. Mature specimens of *E. saligna* measure 5–6 feet in diameter at 6 feet from the ground (Pl. vii, fig. 3; xiii, fig. 55) and attain a height of 130–170 feet with a lateral spread of 50–60 feet. *Syncarpia* is usually slightly smaller than *E. saligna* in diameter, height and spread. Mature specimens of both species have a straight trunk rising above the level of the rain-forest canopy before the lowest branch. Their distribution is discontinuous. *Syncarpia* is relatively abundant in certain localities and absent from others. *E. saligna* is also more numerous in some places than others, but is present throughout most of the forest except in the very deepest creeks, and is generally abundant. As far as could be seen, the distribution of each species is completely independent. Their foliage forms a discontinuous and rather thin canopy, well above the level of the main rain-forest trees. They probably cause little effectual diminution of light to the forest beneath them. Few of the members of this uppermost stratum carry lianes, the only common species being *Lyonsia straminea*. Epiphytes, except for *Cymbidium* on *Eucalyptus*, are very rare. The species *Syncarpia laurifolia* and *Eucalyptus saligna* extend beyond the limits of the rain-forest into the adjacent Eucalypt forest, where in places they constitute the dominant association.

Below the level of the main rain-forest canopy is a small tree stratum including such species as *Diospyros Cargillia*, *Drimys insipida*, *Eupomatia laurina*, *Wilkiea macrophylla*, *Evodia micrococca* var. *pubescens*, and sometimes *Psychotria*

loniceroides (Pl. xiii, figs. 54, 56) and the tree-fern *Alsophila Leichhardtiana* (Pl. vii, fig. 2). This stratum attains a height of 15–30 feet.

Below this is a shrub stratum including species 3–15 feet in height. Most abundant in this is *Citriobatus multiflorus* at the lower levels, and *Drimys insipida* at the upper. These two layers grade into each other completely; species which mature sufficiently to flower and fruit at 6 feet also attain a height of 20 feet. There is, however, a certain concentration at about 5 feet (*Citriobatus*), at 12 feet (*Drimys*, *Wilkiea* and *Eupomatia*), and at 25–30 feet (*Drimys*, *Diospyros* and *Evodia*). Both the small tree and the shrub strata are discontinuous and scanty (Pl. vii, fig. 1), never forming complete layers. The undergrowth is specially sparse below the Eucalypts where, though the canopy may be lighter, there is always a very considerable accumulation of decaying bark and sticks. In these strata must be included tree saplings of all sizes, which are very numerous, and at this stage have very thin stems and few leaves, e.g., a sapling of *Daphnandra micrantha* or *Cryptocarya obovata* 15 feet high may have as few as 24 leaves of laurel-leaf size, the number increasing as the canopy is neared.

The ground stratum comprises mostly ferns and perennial herbs, together with a number of seedlings, and extends upwards to a height of 3 feet. In the mature forest (Pl. vii, figs. 1, 2; xiii, figs. 53, 54) this layer is discontinuous. It is best developed in the moister parts of the forest. Common examples in the dense rain-forest are *Dryopteris decomposita*, *Athyrium umbrosum*, *Adiantum formosum*, *A. affine* and *A. hispidulum*, together with straggling plants such as *Galium*, *Pollia* and *Aneilema*. The two commonest species throughout the forest are the fern *Dryopteris decomposita* and *Lomandra montana*.

The high humidity below the main canopy encourages the growth of Bryophytes and of foliose and crustose lichens. Stones near the river bed and fallen logs (Pl. viii, fig. 17) are covered by a thick layer of mosses and liverworts, the latter being found wherever the substratum is continuously very moist. Mosses are less common on the actual ground surface because of the accumulation of litter, but occasional dense stands of *Dawsonia superba* Grev. (Pl. xiii, fig. 57) and *D. polytrichoides* R.Br. occur, especially on moist banks. The tree trunks are clothed by mosses and crustose lichens, especially the older trees (Pl. vii, fig. 2; xiii, figs. 56, 59).

(b) Inherent Variability.

The tree stratum is the most important in the forest and has received the greatest amount of attention in this study. Within it considerable variation takes place in local composition and in density. This may in places be due to special habitats such as river banks or soakage areas. But when all these factors are taken into account, there remains a variation which does not seem to be explainable on any other basis than that of chance.

This haphazard arrangement is illustrated in Tables 2, 3 and 4, which give the results of 12 sets of quadrats in mature forest, as far as possible avoiding obvious differences of soil, exposure to desiccation and light. It can be seen from this that the commonest species occur in the greatest number of localities, but that they may be much more numerous in some areas than in others. Some of the less common species are common in one locality but are absent entirely from another.

No species can be said to be dominant over the whole of the rain-forest or any considerable part of it. The highest grade of community appears to be the society (as used by Clements, 1916) which emerges occasionally in special habitats over

very small areas. Within the mature rain-forest, however, no species attain sufficient dominance to be said to mark a consociation.

There appears to be no relationship between the relative abundance of any one species and the abundance of any other species in any area. Distribution of each species is quite independent and no definite associations between species could be traced. In one locality, for example, *Schizomeria ovata* and *Sideroxylon australe* were found to be equally abundant, and in another locality where one was abundant the other was lacking or rare. The same condition holds for lianes (Table 3), epiphytes, shrubs (Table 2) and ground flora (Table 4), with the exception of a few species whose distribution will be considered in detail later. It can be seen also that the total number of saplings, shrubs and seedlings is greatly in excess of the total number of trees. The frequency and distribution of all species are indicated in Table 1.

Although no one species of tree can be said to be dominant in any area, the shrubs are not so evenly distributed. *Citriobatus multiflorus* and *Drimys insipida* are dominants in the small tree and shrub strata, *Psychotria loniceroides*, *Eupomatia laurina* and others being much less common. The distribution of the ground flora is more closely related to the environment than that of the trees and shrubs.

(*c*) *Variability due to the Environment.*

Within the mixed rain-forest occur communities of certain species which are characteristic of specific habitats. These form local variations in the rain-forest.

The factors which govern their distribution are light and moisture. The habitats which present conditions slightly different from those in the forest are: (1) lighter and moister, e.g. river banks (Pl. viii, figs. 13, 14, 15); (2) lighter, e.g. due to breaks in the canopy (Pl. vii, figs. 6, 7); (3) moister but not lighter, e.g. soakage areas such as occur at the base of slopes and along the courses of very small creeks (Pl. vii, fig. 8; viii, figs. 16, 17). Swampy patches in the floor of the valley at the bases of the spurs or near the main river are not uncommon. The characteristic plants of these special habitats are as follows:

(1) *Lighter and moister: Weinmannia rubifolia, Alectryon subcinereus, Backhousia myrtifolia, Callicoma serratifolia, Pittosporum undulatum, Tristania laurina, Aneilema acuminatum, Asplenium bulbiferum, Colocasia macrorrhiza, Doodia caudata, Elatostemma reticulatum, Dicksonia antarctica* (Pl. viii, fig. 15), *Lobelia trigonocaulis, Pollia crispata, Pollinia nuda, Lomandra longifolia, L. Hystrix, Oplismenus imbecillus, Urtica incisa, Stellaria flaccida, Viola hederacea, Solanum laciniatum, Diplazium japonicum, Dryopteris acuminata, Galium* spp., *Hydrocotyle hirta, Cardamine hirsuta* var. *tenuifolia.*

The large rivers make a sufficient break to allow light into the forest and along their banks light- and water-loving plants are present in greater numbers, mingled with ordinary members of the rain-forest community (Pl. viii, figs. 13, 14, 15). Along river banks the canopy extends down to ground level (Pl. viii, fig. 14) and epiphytes which characteristically occupy the higher strata of the forest are found at low levels (Pl. xiii, fig. 58). Lianes, which are light-loving species, are often very abundant along the banks of rivers, forming great masses over the tops of the trees and hanging down almost to the water (Pl. viii, figs. 13, 14).

(2) *Lighter: Trema cannabina, Aneilema biflorum, Colocasia macrorrhiza* (Pl. vii, fig. 9), *Dennstaedtia davallioides* (Pl. vii, fig. 9), *Hypolepis tenuifolia, Hydrocotyle hirta, H. tripartita, Passiflora alba, Panicum lachnophyllum, P. pygmaeum, Pteris incisa, P. tremula, Rubus rosaefolius, Solanum laciniatum,*

Lomandra longifolia, *L. Hystrix*. (Lianes also occur in this group, but these will be discussed in detail later.)

(3) *Moister but not lighter: Backhousia myrtifolia*, *Callicoma serratifolia*, *Eugenia australis*, *Ficus stephanocarpa*, *Alsophila Leichhardtiana*, *Aneilema acuminatum*, *Diplazium japonicum*, *Dryopteris parasitica*, *Athyrium umbrosum*, *Elatostemma reticulatum* (Pl. viii, figs. 16, 17), *Pteris comans*.

Creeks do not cause a considerable break in the canopy, and the only difference in the flora may be a concentration of water-loving plants such as *Elatostemma* and ferns in the creek bed. *Alsophila Leichhardtiana* not infrequently forms a zone round a damp creek or soakage area (Pl. vii, fig. 2). It also occurs very frequently in the main forest in damp sheltered areas. A number of trees characteristic of river banks, e.g. *Backhousia myrtifolia*, *Callicoma serratifolia* and *Ficus stephanocarpa*, may be present, forming a creek community, but *Weinmannia rubifolia* is never found, and appears to be an obligate light species.

Areas of forest which were especially shaded showed no significant differences of composition or structure, but some species, e.g. *Blechnum Patersoni*, may be relatively more abundant than elsewhere. Areas which are shaded but dry support a slightly less dense forest, with fewer ferns than the moister areas.

As far as could be seen, no species which grows well in the main forest is unable to grow satisfactorily under conditions of excess moisture and light. There are no significant absences from areas of locally different habitat, such as river banks, of species which are common and widely distributed elsewhere.

(*d*) *Density.*

The number of sample areas is not large enough to generalize for the forest as a whole, but the results confirm the field observations that the density is variable over areas of apparently homogeneous habitat. In Table 5 the density of the vegetation in the quadrat areas is given as number of species per 100 square feet. Shrubs such as *Drimys insipida*, *Psychotria loniceroides*, *Eupomatia laurina* and *Wilkiea macrophylla* are given separately from the saplings of tree species. The tree-fern *Alsophila Leichhardtiana*, *Citriobatus multiflorus* and *Lomandra montana* are also included in the table.

Total vegetation, exclusive of ferns, is on the whole most abundant on the valley floor and lower slopes of the main valley (areas 6, 7, 8, 9, 10). The number of trees higher than 30 feet is also greatest here. Areas 6 and 7 provide exceptions. In area 6, though trees are more numerous than at any other locality investigated, the rest of the vegetation is so scanty that the total is comparatively low. In area 7 the total number of trees is low, but saplings and shrubs are numerous, so that the total is moderately high. With the exception of area 6, in which the density of saplings and shrubs is inversely proportional to the density of trees, no direct relation can be traced between the number of trees, saplings and seedlings or shrubs and ground flora. On the lower valley slopes (areas 3, 5, 11) the vegetation is slightly less dense, and in areas 5 and 11 the trees are fewer than on the main valley floor.

Area 12 shows the density of vegetation in a relatively young piece of rain-forest behind a rapidly advancing margin. The actual structure of the forest is not quite mature and epiphytes are absent, but the percentages of trees, shrubs and saplings fall within the limit of variation of the mature forest.

The lateral gullies show the greatest departure from the valley-floor type. These gullies are mostly very humid and moist, and rather more shaded than the main valley. Tree, shrub and sapling density is lower on the whole, though

the relative proportions of each are similar to those of the flora of the main valley floor. *Alsophila Leichhardtiana* is abundant, reaching its best development on very shaded wet slopes (area 4).

It can be seen that the amount of *Citriobatus multiflorus* is often inversely proportional to the amount of *Alsophila Leichhardtiana*. This can be taken as a measure of the habitat, as *Alsophila* grows in wet shaded areas only and *Citriobatus* prefers the less moist parts of the forest. The density of *Lomandra montana* is fairly evenly low throughout the areas.

The conclusions are supported by field observations which indicate that no very definite relationship can be traced between the density of the flora and its position in the valley. On the whole it appears that the flora is most dense and trees most numerous in the main valley and less numerous in more or less steep-sided tributary-gullies. The canopy of the forest of these lateral gullies is often not significantly less than that of the main valley.

The Rain-Forest Margin.

In any area where two absolutely distinct formations are in contact, it is necessary to determine whether they are stationary with regard to each other, or whether one is encroaching on the other.

If the rain-forest were stationary or retrogressive in relation to the surrounding Eucalypt forest, its margin would be sharply defined, composed of mature but perhaps not large trees; no young rain-forest trees would be present along the margin. A rain-forest which is invading the surrounding Eucalypt forest should show a wide margin of young rain-forest species of gradually decreasing size in the adjacent formation. The width of this zone would therefore be a measure of the relative rate of invasion, but, without detailed investigation over a number of years, no accurate estimate could be given of the actual rate of advance in any area; comparative results only can be given.

A preliminary survey indicated that the rain-forest area is advancing into the Eucalypt-forest area around all its edges with the exception of the uppermost one. The rapidity with which the advance is taking place varies with the aspect and degree of slope. The following types of margin may be distinguished, but it must be remembered that they are only arbitrary divisions of a continuous series.

(*a*) *Slowly-advancing Margins.*

In this type the rain-forest is almost stationary, its edge is very well defined, and the change from Eucalypt forest to rain-forest takes place over a distance of only a few yards (Pl. ix, fig. 18). A few fairly large, old rain-forest trees are present in the adjacent forest and a few young ones may also be present. This type of edge is characteristic of dry or steep exposed slopes and of the lower edge of the forest. It abuts on *Eucalyptus saligna–E. amplifolia* or *E. saligna–E. acmenioides–Casuarina torulosa* forest, with *Casuarina Cunninghamiana* and *Callistemon salignus* in damp places. The commonest species of the rain-forest edge of this type are *Ackama Muelleri* and *Trochocarpa laurina*; both often bear a number of epiphytes. Lianes may be present, in some cases forming a definite community (Pl. x, fig. 29). This condition is never found on rapidly advancing margins.

(*b*) *Intermediate Type of Margins.*

In this type the rain-forest is advancing slowly and steadily. Since the forest immediately surrounding the rain-forest is dominated by *Eucalyptus saligna* and *Syncarpia laurifolia*, the trees of this formation which have been recently engulfed

are not especially conspicuous. The rain-forest edge is marked by some thickets of trees varying in height from 2 feet to 20 feet (a height which in this position could be gained in 2–5 years). Most frequently these thickets are fairly homogeneous over small areas, all consisting of the same species, but at other places several species may be concerned. At this stage they are usually far more closely spaced than in the mature rain-forest, and it is apparent that only a small percentage of them could survive. These thickets are backed by fairly large but not mature trees forming a rain-forest formation of typical structure (Pl. ix, figs. 21, 25). A community which is very common along the edges of these types of margins is a tree-fern one, consisting of *Alsophila australis* (Pl. ix, fig. 20) which is found only in damp sheltered positions around the edges of the rain-forest. It is commonly associated with fairly large trees of *Ackama Muelleri* (Pl. ix, fig. 19). This type of edge is found along the sides and heads of sheltered creeks and on sheltered slopes.

(*c*) *Rapidly-advancing Margins.*

All gradations between this type of margin and the intermediate type can be seen. Fairly numerous young colonists of all kinds, many of them locally forming pure stands, occur along the edges (Pl. ix, fig. 22). Often these extend irregularly into the grassland or Eucalypt forest (Pl. x, fig. 28), whereas the slow and intermediate types show a more or less even front (Pl. ix, fig. 25). Species from the herb and shrub strata of the Eucalypt forest are present amongst the young rain-forest types (Pl. x, fig. 27). This in itself is an indication that the advance is fast, since these species are apparently very light-sensitive and die quickly as the light is decreased. Such a community is not found in the more slowly advancing edges. Behind these pioneer communities are progressively larger trees (Pl. ix, figs. 23, 24), until the mature forest is reached. At a distance from the edge the Eucalypt-forest types are absent and the rain-forest species are not so closely set, indicating that a natural thinning process has occurred. The width of this transition zone between margin and mature forest depends on the rapidity with which the forest is advancing. In some places it is evident that young rain-forest advancing up creek beds has been able to tap a new area suitable for growth, such as a flat part of a spur receiving soakage from steep slopes above (Pl. x, fig. 26). In such regions as this, advance takes place very rapidly. Some advancing margins consist of young trees very closely spaced together (Pl. ix, figs. 23, 24; x, fig. 28). In others the spacing is more open. Open spacing appears to be a characteristic of slightly drier slopes (Pl. x, fig. 27). At first there is no continuous canopy unless the saplings are very closely set. A continuous canopy forms as the forest increases in height.

In the advancing types of margin, lianes are as a rule relatively uncommon in the younger parts and do not assume a leading rôle until the forest has reached a height of about 40 feet. The shrubs, ground flora and epiphytes typical of the mature rain-forest also follow the invasion of trees and are not as a rule found in the younger parts of the margin (Pl. ix, fig. 24). In the younger parts, *Blechnum cartilagineum* and *Dryopteris decomposita* alone of the ground flora occur in any quantity (Pl. ix, fig. 23).

Most of the margins, even if slowly growing or almost stationary, have behind them a zone which is not mature. This immature part constitutes a considerable part of the total rain-forest (Pl. vii, fig. 5). It is impossible to tell, without a study of the annual rings of the component trees, the actual rate of advance, but it is evident that, in the case of the rapidly-advancing margins at least, much Eucalypt forest must have been invaded in historic times.

The advance species of wet rain-forest margins such as occur on a recently-colonized hillside with soakage may differ from those on a dry slope. Those commonly present in wet areas are: *Tristania laurina, Eupomatia laurina, Ackama Muelleri, Hypolepis tenuifolia, Histiopteris incisa,* and *Rubus* spp. The chief feature is the relative abundance of ferns (Pl. x, fig. 26). Ferns, on the other hand, do not play a conspicuous part in the colonization of dry slopes, where they are often entirely absent. Common species in dry areas are *Elaeodendron australe, Elaeocarpus reticulatus, Cryptocarya microneura, C. patentinervis,* and *Ackama Muelleri.*

Almost every rain-forest species has been found to occur in the advancing zone, though some species are common while others are rare. Their abundance, as far as could be judged, depends largely on their presence or absence in the adjacent forest, and must also depend greatly on chance, e.g. the production of seeds during a season favourable for their germination and establishment. Amongst the more common rain-forest species which are important in the margins are *Ackama Muelleri, Cryptocarya microneura, C. patentinervis, Elaeocarpus obovatus, Rapanea Howittiana, Schizomeria ovata, Synoum glandulosum,* and *Tristania laurina.* Species which have not been observed in margin communities are *Sloanea australis, Emmenospermum alphitonioides, Chariessa Moorei, Cryptocarya obovata, Litsea reticulata, Pennantia Cunninghamii.*

(*d*) *True Margin-Communities.*

There are a number of species which are characteristic of the lower rain-forest margin, and are not found commonly elsewhere in the formation. They are found often in moist sheltered places. The most common species are: *Alsophila australis, Clerodendron tomentosum, Commerconia echinata, Croton Verreauxii, Hedycarya angustifolia, Hibiscus heterophyllus, Melothria Cunninghamii, Myrtus Beckleri, Homalanthus populifolius, Sicyos angulata, Solanum verbascifolium, Trochocarpa laurina,* and *Zieria Smithii.* The composition of this margin flora varies from place to place; any of the above species may be locally dominant over a small area or absent altogether. This margin-community only occurs round the edge of almost stationary rain-forests, especially near creeks. A complete list of species found in this type of locality is given in Table 1, Column 3.

(*e*) *The Upper Margin.*

The main part of the sub-tropical rain-forest occurs in the valleys below 1,500 feet, but deep gullies and soakage areas on the sheltered slopes of hills allow its extension upwards to an altitude of about 3,000 feet. Most of the higher part of the rain-forest is of necessity developed on steep slopes, but occasional flat areas may occur along the upper part of creeks just below the main level of the range, and it is here that the upper part of the sub-tropical rain-forest is best developed.

Above about 1,800 feet the rain-forest is developed on soil derived from basalt, but, as far as could be seen, this was not responsible for any significant floristic change. The structure of the rain-forest remains unchanged (Pl. xi, fig. 38) until near its upper limits, but although the tree, shrub and ground flora strata maintain their relationships, a gradual reduction takes place in the number of species present, as higher altitudes are approached. Such trees as *Baloghia lucida, Sideroxylon australe,* and *Sloanea australis* which are common in the lower rain-forest, gradually fade out about 1,500–2,000 feet, *Crytocarya* spp. and *Endiandra* spp. about 2,000–2,500 feet, and then *Daphnandra micrantha* and *Laportea gigas.*

The common tree species of the higher rain-forest are *Dysoxylum Fraseranum, Eugenia Smithii, Ackama Muelleri, Doryphora sassafras, Orites excelsa, Tieghemo-*

panax Murrayi, Schizomeria ovata and *Eucalyptus obliqua.* Common species of the lower strata are *Dicksonia antarctica, Alsophila australis, Pteris umbrosa* (Pl. xi, fig. 38), *Adiantum formosum, Lomandra montana, Elatostemma reticulatum, Australina pusilla, Pellaea falcata, Pleopeltis pustulata, Doodia aspera, Dryopteris decomposita, Arthropteris tenella, Histiopteris incisa, Citriobatus multiflorus, Gymnostachys anceps* and *Rubus parviflorus.* The epiphytic species *Asplenium nidus, A. adiantoides* and *Pleopeltis Brownii* frequently occur, and lianes include *Aralia cephalobotrys, Cissus antarctica, Dioscorea transversa, Smilax australis, Palmeria scandens* and *Tecoma australis.*

Dicksonia antarctica is abundant in moist and slightly light areas. At the highest altitudes lianes and the tree-top epiphytes become less abundant.

The sub-tropical rain-forest stops entirely just below the winter snow line, at about 3,000 feet. Where it abuts on the Eucalypt forest at its upper margin it appears to be almost stationary, and is not advancing into either the Eucalypt forest or the sub-antarctic rain-forest. The "corkwood" *Ackama Muelleri* forms communities around the margin and is the most common and conspicuous species here. Small gnarled trees of this species, about 20–35 feet high and evidently of considerable age, are present in the adjacent woodland. It appears to be more resistant to cold than most of the sub-tropical rain-forest species. *Alsophila australis* is absent at these high levels. Other species commonly found are *Trochocarpa laurina, Astrotricha floccosa, Doryphora sassafras, Acacia melanoxylon, Hymenosporum flavum, Tieghemopanax sambucifolius, Tristania laurina* (the last three as shrubs 2–6 feet high), *Dicksonia antarctica,* all mostly stunted. Small trees of *Nothofagus Moorei* are also present at about 3,500 feet and above. Mosses and lichens are abundant on tree trunks and rocks in the margin at this level.

Outliers.

The main forest of the Williams River valley does not extend along the river below the altitude of about 1,000 feet. Subsidiary areas of rain-forest which are best termed outliers occur in three types of habitat in the lower valley. The largest areas occur in the valleys of creeks which enter the river below the lower limit of the main rain-forest. In the case of the Williams River the first two creeks below the rain-forest margin have a rain-forest flora extending along their valleys almost to the junction with the main river (Map 1, Part 1; these Proc., 1937, p. 272). Below that the rain-forest outliers become more and more restricted to the upper parts of the creek beds and finally are absent even from these. The outliers furthest from the main rain-forest consist only of a few trees and some lianes. The larger outliers are similar in structure and composition to the main forest.

A feature of the two main outliers of the Williams River valley is the presence of large trees of *Tristania conferta* approaching 120 feet in height and 2 feet 6 inches in diameter in the forest and along the margin. In the main forest only a few trees of this species are present at the lower margin. Other species apparently restricted to the lower outliers are *Pithecolobium pruinosum* and *Tetrastigma nitens.*

Another type of outlier may be termed the "soakage outlier". It is found at the bases of hills sheltered from the west where the tilt of the rocks is such that soakage occurs and drainage collects (Pl. xii, fig. 50). These may be up to an acre in extent or may consist of only a few trees with lianes (Pl. xii, fig. 51). Isolated rain-forest trees, usually of considerable size, occur rarely on sheltered

hillsides or river flats well below the limit of the ordinary outlier. Common species are *Cedrela australis, Alphitonia excelsa, Cryptocarya glaucescens, Duboisia myoporoides, Hymenosporum flavum,* and *Pittosporum undulatum.* In most cases the Eucalypt forest which once surrounded these outliers has been cleared so that they now appear in the middle of pasture country. They are mature in structure and few young plants are present. They are probably fairly static, as the surrounding habitats are not suitable for their further development. They are exposed to greater extremes of heat and cold and greater variation in humidity, and receive more light than the trees of the main forest, but have not less available water. In the Williams River valley species in this type of outlier are: (Trees) *Acacia melanoxylon, Alphitonia excelsa, Codonocarpus attenuatus, Commerconia echinata, Cryptocarya patentinervis, Diploglottis Cunninghamii, Ehretia acuminata, Eugenia Smithii, E. australis, Guoia semiglauca, Hibiscus heterophyllus, Hymenosporum flavum, Laportea gigas, Scolopia Brownii, Trema cannabina*; (Shrubs) *Croton Verreauxii, Clerodendron tomentosum, Wilkiea macrophylla, Notelaea venosa*; (Lianes) *Legnephora Moorei, Cudrania javanensis, Dioscorea transversa, Lonchocarpus Blackii, Passiflora alba, Arthropteris tenella, Sarcopetalum Harveyanum, Smilax australis, Rubus Moorei, Tecoma australis,* and *Cissus antarctica.* Several species occur commonly in these outliers which are not present in the main rain-forest, namely, *Legnephora, Codonocarpus,* and *Lonchocarpus.*

A third type of outlier is found along river banks. Isolated rain-forest trees extend along the river for a considerable distance below the margin of the main rain-forest (Pl. xi, fig. 35). Along the Williams River they extend for about 10 miles, becoming gradually fewer and more stunted. A few of the hardier epiphytes and ferns, e.g. *Dendrobium* spp., *Cyclophorus serpens,* and *C. confluens.* are prominent in this type of outlier. *Casuarina Cunninghamiana,* which in the Eucalypt forest forms communities along river banks, is present amongst the colonists, together with *Acacia melanoxylon* and *Angophora subvelutina. Casuarina* extends upwards along the river banks for about 1 mile into the main rain-forest.

Regeneration.

The structure described for the rain-forest is based on the mature and, as far as could be ascertained, the undisturbed parts of the forest. Considerable disturbance has taken place in parts of the forest due to timber removal, and this has given opportunities for the study of regeneration.

(*a*) *Regeneration after Slight Destruction.*

Slight destruction is due to the felling and hauling out of one tree, or the natural falling of an old tree overweighted with lianes and epiphytes. As all of the trees of the main stratum are more or less connected with their neighbours by lianes, this results in the bringing down of a mass of lianes and parts of the neighbouring trees. The undergrowth may be broken to some extent, but not destroyed. This results in a greatly increased amount of light reaching the lower strata. Such areas have been termed light breaks. Young trees which are always present in the mature forest, take immediate advantage of the light and grow rapidly. If fresh earth is uncovered by the torn up roots, *Lobelia trigonocaulis, Hydrocotyle hirta, Galium australe* and other herbs are often amongst the first colonists. The young trees are stimulated to the production of numerous leaves on the lower as well as the upper branches, but tall mature trees remain unchanged.

A light break stimulates an immediate increase in the density and, to a certain extent, in the number of species of ferns of the ground flora (Pl. vii, figs. 7, 9; viii, fig. 12). *Dennstaedtia davallioides*, *Hypolepis tenuifolia* and *Histiopteris incisa* are the most characteristic species, but *Dryopteris decomposita*, *Adiantum* spp., and *Blechnum cartilagineum* are also favoured and, if present before the break took place, increase in luxuriance. In damp places, *Pollia* (Pl. vii, fig. 8), *Colocasia* (Pl. vii, fig. 9), *Aneilema* and *Athyrium umbrosum* may be the chief colonists and may form extensive and almost pure communities. Small lianes (Pl. vii, figs. 6, 9), such as *Rubus* spp., *Melothria Cunninghamii*, *Sicyos angulata*, *Convolvulus marginatus* and *Passiflora alba*, are also found commonly in damp light breaks.

If the break is fairly extensive, *Eucalyptus saligna* usually regenerates in large numbers (Pl. viii, figs. 11, 12), and dense thickets of young saplings are found in old breaks. It is often possible to locate old light breaks by the presence of a fairly large number of Eucalypts in a small area. This species is found in the sapling stage only in light breaks. *Syncarpia laurifolia* rarely regenerates in small light breaks. The rain-forest may therefore regenerate fairly quickly into the mature forest again. Secondary areas such as this do not appear to be more dense than the primary forest, as, with the exception of the *Eucalyptus* seedlings, few new seedlings become established, and the permanent regeneration is due to the growth of the young trees present before the break took place.

If, however, large lianes rooted in the area are brought to ground level by the fall of the tree which supported them, their young growth, backed by a fully developed root-system, is more vigorous and fast growing than any young tree, with the exception of *Eucalyptus*. They are able to root wherever their stems touch the ground, and so spread further afield. Consequently the liane is able to cover young shrubs rapidly and form thickets, often about 10 feet high and quite impenetrable. In some cases the trees may be able to keep pace and raise themselves and their load to the level of the canopy, where, once having obtained their full vigour, their relations with the lianes assume their proper proportion (cf. Pl. vii, fig. 7). In other cases it is evident that the lianes completely smother the vegetation beneath and, by cutting out much light, so weaken it that it remains as a liane community for a long period. The ground flora under such a thicket is very scanty.

(*b*) *Regeneration after Complete Destruction.*

A few areas were found in the rain-forest, mostly near the margin, where disturbance had resulted in total destruction of the flora over an acre or more. Since the ground is mostly very wet, logging and trampling of bullock teams causes it to be cut up easily. After disturbance has ceased in such an area recolonization commences immediately. Tree, shrub and herb members of the forest floor, as well as some weeds introduced during the disturbance, all commence to grow at the same time on an equal footing (Pl. viii, fig. 10). The species commonly found first in these situations are herbaceous, e.g., *Cynoglossum latifolium*, which is able to cover large areas quickly and produces seeds very prolifically, *Lobelia trigonocaulis*, *Galium australe*, *Panicum pygmaeum*, *Hydrocotyle hirta*, *H. tripartita*, *Callitriche verna*, *Solanum* spp. and *Poa caespitosa*. Shrubs and small trees such as *Croton Verreauxii*, *Rhodomyrtus psidioides*, *Duboisia myoporoides*, and *Rubus rosaefolius* are also common. *Eucalyptus* seedlings are usually very abundant and *Syncarpia* seedlings also occur. Liane

seedlings are inconspicuous at this stage. The tallest shrubs occur round the margins of such areas where destruction may not have been so severe (Pl. viii, fig. 10, left side).

No single rain-forest species appears to be particularly favoured by these breaks, a wide variety of species being found mingled with the rain-forest edge species. Communities of large numbers of the same species are rare, but they have been seen in other localities (Pl. x, fig. 33). Colonization may therefore be due to seed-production by a single species at an appropriate time, or to seeds which have lain dormant for years in the soil and have been able to take instant advantage of favourable conditions.

Along the breaks formed by permanent tracks light-loving species are common. *Callitriche verna, Croton Verreauxii, Rubus rosaefolius, Panicum pygmaeum, P. lachnophyllum* and various ferns border the track on both sides.

Unused log tracks are colonized by seedlings from the adjacent forest. Pioneer species such as *Callitriche verna* (in holes where water collects), *Lobelia trigonocaulis, Solanum* spp., and *Panicum* spp. may precede the permanent flora. When the log tracks pass through mature forest, however, they usually do not cause the formation of a light break and colonization is slow, especially in dry places. Several such tracks were observed, still recognizable though practically unused for 10 years. In the drier parts of the forest such tracks are occupied only by a few ferns and seedlings. In the damp parts, however, they soon become obliterated by thickets of ferns and such herbs as *Pollia crispata.*

The species characteristic of the disturbed areas are: (Shrubs and small trees) *Acronychia laevis, Callistemon salignus, Croton Verreauxii, Duboisia myoporoides, Ehretia acuminata, Homalanthus populifolius, Solanum laciniatum, S. pungetium, Rubus rosaefolius;* (Lianes) *Melothria Cunninghamii, Dioscorea transversa;* (Herbs) *Aneilema acuminatum, A. biflorum, Acaena sanguisorba, Anagallis arvensis, Adiantum formosum, Callitriche verna, Colocasia macrorrhiza, Cynoglossum latifolium, Geranium molle, Hypolepis tenuifolia, Hydrocotyle hirta, H. tripartita, Lobelia trigonocaulis, Panicum lachnophyllum, P. pygmaeum, Pollia crispata, Polygonum hydropiper, Pteridium aquilinum, Pteris tremula, Plectranthus parviflorus, Oplismenus imbecillus, Siegesbeckia orientalis, Urtica incisa, Viola hederacea.*

(*c*) *Regeneration along the Lower Rain-Forest Margin.*

The lower edge of the rain-forest abuts on a woodland of *Eucalyptus saligna, E. amplifolia* and *Callistemon salignus.* In moist places destruction of the rain-forest margin results in the growth of thickets of *Callistemon* (Pl. x, figs. 31, 32), *Eucalyptus* (Pl. x, fig. 30) and *Acacia mollissima,* which appear to be able to regenerate more quickly than the forest species. On the edges of these thickets such species as *Colocasia macrorrhiza* (Pl. x, fig. 32), *Rubus rosaefolius, Litsea dealbata, Cryptocarya microneura* and the typical rain-forest margin species are present.

Destruction in dry places usually results in the regeneration of rain-forest and Eucalypt-forest species in the same proportion as existed previously. Occasionally thickets of *Acacia* may occur, or dense stands of *Culcita dubia.*

(*d*) *Regeneration of Outliers.*

The regeneration of the *Eucalyptus* spp. is quicker than that of the rain-forest species when abundant material is at hand as a source of seed. If the Eucalypt forest is destroyed for pasture land, no such source of seed is available.

Consequently, if an outlier of rain-forest in a cleared area is partially destroyed, as by fire or clearing, it regenerates to rain-forest again. This can be frequently seen in gully heads or shaded hillsides (Pl. x, fig. 34).

(*e*) *Methods of Regeneration.*

Some species are able to regenerate by means of root suckers, e.g., *Litsea dealbata*, *Sloanea australis*, *Cedrela australis* and *Cissus* spp. This ability is possessed only by a few, so that regeneration of a destroyed area of rain-forest is chiefly by seed or from the undestroyed base of the stem.

In the area under investigation, no extensive areas have been denuded by clearing, and the detailed methods of regeneration of the main rain-forest under these conditions are not known.

Special Features.

(*a*) *Epiphytes.*

Epiphytes are indicators of humid atmospheric conditions. The atmosphere of the rain-forest below the canopy is very humid for the greater part of the day and, even at the level of the canopy, dry conditions are never very prolonged. All the rain-forest trees, with the exception of *Eucalyptus saligna*, have rather rough bark which forms an ideal foothold for mosses and lichens.

Large mosses (e.g., *Hypopterigium* sp.) are common on rocks and decaying logs, and extend some distance upwards on the trunks of the trees in gullies or near the river, where humidity is highest. Most of the mature trees, both in gullies and in the main forest, have masses of short mosses (*Macromitrium*, etc.) and foliose lichens as far as the shorter branches (Pl. vii, fig. 2; xiii, figs. 54, 56, 59). Long trailing masses of the moss *Papillaria* are common on the undershrubs and hanging from the lower boughs of the trees (Pl. vii, fig. 8). This mantle of mosses and liverworts does not occur on the trunks of the Eucalypts which decorticate every year (Pl. vii, fig. 3). A considerable growth of the liverwort *Lepidozia* sp. and certain mosses occurs at the extreme base of the trunks (the lowest 2–5 feet), where a dead, fibrous layer of bark persists (Pl. xiii, fig. 55). Epiphytic mosses and liverworts are uncommon on the trunks of *Syncarpia* (Pl. viii, fig. 12).

The epiphytic moss species form a very suitable matrix for the development of epiphytic orchids and ferns (see Table 1). Most of these species are found in the higher levels of the canopy where they obtain most light. Tree species such as *Ackama Muelleri*, *Dysoxylum Fraseranum*, *Ehretia acuminata* and *Schizomeria ovata*, are always densely crowded with epiphytes. *Sloanea australis*, which has a relatively much thicker canopy, usually supports a less rich flora, except near the very top. Other than the Bryophytes and lichens, almost all the epiphytes belong either to the ferns or the Orchidaceae, *Peperomia reflexa* (Piperaceae) being a notable exception.

Four classes of epiphytes, exclusive of Bryophytes and lichens, can be distinguished on the basis of their distribution:

(1) Species of very open and exposed situations, e.g., *Cymbidium suave*.—This is not really a rain-forest species and is more common in the Eucalypt forest. It occurs exclusively on *Eucalyptus saligna* in pockets caused by the fall of branches, and above the level of the rain-forest canopy.

(2) Obligate light species, e.g., *Dendrobium speciosum*.—This species is found only on the topmost branches of trees along the river bank, where it gets

maximum light and considerable humidity for part of the day. It extends along the river for a considerable distance below the margin of the rain-forest.

(3) Facultative light species.—This group comprises the majority of the rain-forest epiphytes, e.g., *Dendrobium gracilicaule*, *Asplenium nidus*, *Davallia pyxidata*, *Platycerium bifurcatum*, *Cyclophorus confluens*, *Pleopeltis Brownii*, *Peperomia reflexa* and many others (Pl. xiii, figs. 56, 58). They are found near the top of the canopy, often in masses of considerable size, comprising as many as six different species. Some species, e.g., *Cyclophorus confluens*, are also commonly associated with *Dendrobium speciosum*. Within the rain-forest epiphytes of this class occasionally occur below the canopy in rather shaded places, but their growth is not usually so vigorous as it is higher up (Pl. xiii, fig. 55).

(4) Shade species, e.g., *Bulbophyllum* spp. (frequent), *Sarcochilus* spp., *Trichomanes caudatum*, *Hymenophyllum tunbridgense*, and *Asplenium adiantioides*.—In this section also may be placed the climbing ferns *Arthropteris Beckleri*, *A. tenella* and *Pleopeltis pustulata*, which, though rooted in the ground, send rhizomes up the trunks of trees, to which they cling closely, sometimes attaining a height of 20–30 feet, and invading the stratum of class 3 (Pl. viii, fig. 17, left, and xiii, fig. 60).

With two exceptions, the distribution of the epiphytes appears to be unconnected with the species of tree on which they grow. One of these is *Cymbidium suave*, which grows in decaying branch gaps of *Eucalyptus* spp. The other is *Sarchochilus Hillii*, which is almost invariably found only on *Backhousia myrtifolia*, near streams or rivers; it is likely that the habitat in which it grows, i.e., relatively light, humid localities near water, rather than any actual property of the tree, is responsible for this distribution.

(b) Climbers.

Lianes are common throughout the forest. Their stems, especially those of species of *Cissus*, form festoons around the larger trees and lie in coils on the floor of the forest (Pl. vii, figs. 1, 7; viii, figs. 15, 16; xiii, figs. 53, 56). They may be grouped either according to their size and relation to the canopy, or according to their climbing mechanism.

On the basis of size they may be grouped in the following manner:

(1) Very large, e.g., *Cissus antarctica*, *C. hypoglauca*, *Lyonsia straminea*, *Palmeria scandens*, *Celastrus australis*, *Piper Novae-Hollandiae*. With the exception of the last species, these lianes develop considerable trunks, up to 6 inches in diameter, and a single plant may cover the canopies of several trees 100 feet or more in height (Pl. viii, figs. 13, 14).

(2) Large, e.g., *Chilocarpus australis*, *Embelia australasica*, *Malaisia tortuosa*, *Morinda jasminoides*, *Tecoma australis*, *Cayratia* sp., *Rhipogonum album* and *Smilax australis*. These species may reach the level of the canopy, but do not spread very far, and do not develop large thick trunks.

(3) Small, e.g., *Aralia cephalobotrys*, *Dioscorea transversa*, *Tylophora barbata* and *Aphanopetalum resinosum*. These rarely reach the canopy of the mature forest, and are most frequent along river banks or other light breaks. In the mature forest they are small and rarely flower.

(4) This class includes climbing species which are typical of the rain-forest margins, and are not found in the mature forest, except rarely in light breaks, e.g., *Sarcopetalum Harveyanum*, *Stephania hernandifolia*, *Sicyos angulata*, *Melothria Cunninghamii*, *Cayratia clematidea* and *Billardiera scandens*.

On the basis of climbing mechanisms the following classes can be distinguished:

(1) Twiners, e.g., *Aralia cephalobotrys, Morinda jasminoides, Chilocarpus australis, Dioscorea transversa, Malaisia tortuosa, Embelia australasica, Tylophora barbata, Tecoma australis, Billardiera scandens, Stephania hernandifolia* and *Sarcopetalum Harveyanum.*

(2) Tendril climbers, e.g., *Cissus* spp., *Cayratia* spp., *Sicyos angulata* and *Melothria Cunninghamii.*

(3) Adventitious root climbers, e.g., *Piper Novae-Hollandiae* and *Lyonsia straminea.*

(4) Stragglers, e.g., *Smilax australis, Rhipogonum album, Palmeria scandens, Celastrus australis* and *Aphanopetalum resinosum.*

Most of these lianes are very weak climbers, and it appears evident that they reach the canopy largely by being carried up by the growth of young trees. During this process large stems are produced which sprawl over the forest floor. This is especially the case with *Palmeria, Smilax* and *Rhipogonum.* Only two species (of *Piper* and *Lyonsia*) are able to reach the canopy without assistance in any other way. These species, possessing adventitious roots, can climb straight up the trunk of a large tree. *Lyonsia* is the only liane to be found on *Eucalyptus saligna.* This tree has a smooth bark which is shed every year; thus in order to climb it successfully, a liane must possess strong adventitious roots and a very fast growth rate.

Once the canopy is reached, most lianes sprawl over the tops of the trees, the stems being stiff enough to bridge short intervals. *Piper Novae-Hollandiae* has very weak stems, and characteristically hangs in long trailing masses of several intertwined branches from the tops of trees often nearly to the ground.

(*c*) *Pulvini.*

Pulvini are almost universal amongst the rain-forest trees. They are absent from some of the shrubs. The following species have not been observed to develop pulvini: *Trema cannabina* (Ulmaceae), *Cudrania javanensis* (Moraceae), *Laportea gigas* (Urticaceae), *Hymenosporum flavum* (Pittosporaceae), *Duboisia myoporoides* (Solanaceae), *Clerodendron tomentosum* (Verbenaceae) and *Psychotria loniceroides* (Rubiaceae).

(*d*) *Leaf Characters.*

The leaves of the majority of rain-forest tree species belong to the mesophyll leaf-size class of Raunkiaer (1934). Drip tips are prominent on the leaves of most of the tree species, but the undershrubs show much more variation both in leaf-size and shape. Domatia are a feature of the leaves of some species. Most commonly they occur in the axils of the main and lateral veins, or at the junction of two lateral veins. Those species which invariably show the presence of domatia are *Pennantia Cunninghamii, Endiandra Muelleri, E. discolor* and *Dysoxylum Fraseranum.*

(*e*) *Seed Characters.*

Seeds produced by the rain-forest trees are for the most part large, especially when compared with those of species characteristic of the Eucalypt forest, and of *Eucalyptus* spp.

(*f*) *Root Systems and Buttresses.*

These observations are based on trees which had fallen, and whose root systems were partially exposed. In all such cases observed the root systems were

very shallow, all the major roots being close to the surface of the ground. Often the major roots can be traced some distance from the tree along the surface of the ground (Pl. xi, fig. 38). This is especially well marked in the case of *Laportea gigas*, whose roots have been traced 20–30 feet from the main trunk.

A very complete description of buttressing in Australian rain-forest trees is given by Francis (1929). The large buttresses described for the northern rain-forests do not occur in the Williams River district, and true buttresses are rare. In the Williams River rain-forest the type of buttress approaches that described by Francis as a flanged stem (Pl. xiii, fig. 54). Here, when well developed, the largest buttresses extend 8–10 feet up the stem and stand out from it several feet, being continuous at the base with the upper sides of roots (Pl. xiii, figs. 53, 60). They are comparatively thick, being much thicker than those of the northern rain-forests. The best developed specimens are found on the following species: *Sloanea australis* (Pl. xiii, fig. 60), *Ackama Muelleri*, *Cryptocarya glaucescens*, *Diploglottis Cunninghamii*, *Doryphora sassafras*, *Dysoxylum Fraseranum* (Pl. xiii, fig. 53), *Pennantia Cunninghamii* and *Schizomeria ovata*. They are usually thick, and extend upwards and outwards to an extent dependent on the size of the tree. The following measurements illustrate this:

Species.	Tree.		Buttresses.		Remarks.
	Height.	Diameter.	Vertical Extent.	Horizontal Extent.	
	Feet.	Feet.	Feet.	Feet.	
Sloanea australis ..	50	1	2½	4	Very thick.
„ „ ..	60	1¼	2	3	„ „
Schizomeria ovata ..	90	5	15	6	„ „
„ „ ..	40	1¼	3	3½	„ „

A variation of this is sometimes found, in which the trunk of the tree has several longitudinal furrows, between which it bulges slightly. This structure extends for 6–15 feet up the trunk of the tree, and appears to be restricted to certain species, notably *Diospyros pentamera* (Pl. xiii, fig. 54) and *Doryphora sassafras*. In other cases very small shallow thick buttress-like swellings occur at the very base of the stem, where the main roots emerge.

These phenomena are not found throughout the whole extent of the rain-forest. The best developments of buttresses are always found in the deepest parts of the rain-forest where the soil is permanently very wet and evaporation less at the level of the canopy than elsewhere.

All observations support Petch's (1930) theory that buttresses are the result of a shallow root-system, and lack of a tap root, leading to increased growth of the stem above the point of emergence of the roots.

Allied Rain-Forest Areas.

(*a*) *The Allyn River Valley.*

The rain-forest of the upper Allyn River valley resembles that of the Williams so closely that it can be considered to belong to the same association. The differences that occur are of no greater significance than variations between

different parts of the Williams River forest. Types of margins and upper margin communities are similar in both valleys, and may merge into each other over the Williams Range in places partially sheltered from the west. The upward extent of the rain-forest margin is dependent, as in the Williams valley, on the degree of exposure. On the steep, exposed, westerly-facing slopes of the Williams Range its margin is some 500 feet below the margin on the easterly-facing slope of the valley, but in places where sheltered valleys have been cut by tributary streams, the rain-forest margin is equally high on either side.

The lower part of the valley is more open and exposed than the Williams valley and supports a thinner, more open, younger type of rain-forest. This forest is characterized by a few large trees, between which smaller, younger trees occur. In places the canopy is thin, and a relatively large amount of light gets through to the ground flora. Consequently the ground flora is much more thickly developed than in the mature parts of the forest. Ferns are less important than in the main part of the rain-forest. The most important species of the ground flora are *Gahnia melanocarpa, G. aspera, Gymnostachys anceps, Cyperus appressa, Lomandra montana,* and *Dryopteris decomposita.*

Outliers similar in distribution and structure to those in the Williams valley occur in the Allyn valley. Common species are: *Evodia micrococca, Litsea dealbata, Aphananthe philippinensis, Legnephora Moorei, Cryptocarya glaucescens, Cedrela australis, Mallotus philippinensis, Cudrania javanensis* and *Cissus* spp.

As in the case of the Williams valley, some species occur in the outliers which are not found in the main rain-forest, notably *Legnephora Moorei, Aphananthe philippinensis* and *Mallotus philippinensis. Aphananthe* and *Mallotus* have not been found in the Williams River valley.

A prominent feature of the valley floor below the rain-forest and near the river is the presence of outlier trees of rain-forest species, especially *Cedrela australis.*

(*b*) *The Chichester River Valley.*

The Chichester River valley is wider and more dissected than the Williams, but is fairly well protected from the west. The soil appears to be slightly more sandy than that of the Williams River valley because of the outcropping of granitic rock.

The structure of the mature rain-forest is similar to that of the Williams and Allyn valleys. So far as could be observed, the trees that are common, frequent, sporadic or rare in the Chichester rain-forest are present in much the same proportions as in the Williams valley. The same grouping of species, both of the tree stratum and the shrub and ground flora, is evident. One tree species only, *Sloanea Woollsii,* was collected which has not been observed in the Williams River rain-forest.

The lower part of the Chichester rain-forest is quite distinct from anything found in the Williams valley. It is of a thin type, indicating that it is young, in which respect it resembles the lower Allyn River rain-forest. The canopy is in places thin and even slightly interrupted, grasses, *Gahnia* spp. and *Lomandra* spp., forming the bulk of the ground flora in these breaks, ferns being less common. The individual trees are slightly smaller, and less closely spaced than in the mature rain-forest. The chief point of difference, however, is the presence of *Tristania conferta.* This species occurs throughout the rain-forest here, but is especially abundant near the river, and extends for a short distance into the surrounding Eucalypt forest. It approaches in size *E. saligna* (i.e., about 150 feet high with a

diameter of 4 feet), with which it is associated (Pl. xii, fig. 49). The comparatively open, sunny nature of the lower rain-forest is shown especially by the nature of the river-bank flora, where, in addition to numerous lianes, *Casuarina Cunninghamiana*, *Acacia melanoxylon* and *A. elata* are present. Throughout the lower rain-forest the river bank is occupied by a herb community of *Lomandra longifolia*, *Gleichenia flabellata* and *Blechnum discolor* (Pl. xii, fig. 48). This community does not intrude into the forest for more than a few feet, except in wet, light places, where thickets of *Gleichenia* may be present. It is absent from the banks of the river in the upper dense rain-forest where the river banks are overhung by trees. A list of the species observed in the rain-forest of the Chichester River valley is given in Table 6, column 1.

The structure of the margins is similar to that in the Williams River rain-forest. The following species are common margin constituents: *Callicoma serratifolia*, *Tristania conferta*, *Ackama Muelleri*, and *Trochocarpa laurina*.

Outliers occur, and are similar to those previously described, but are less extensive, as the valley is less sheltered and is largely cleared below the lower margin of the rain-forest. The following species were found in the outliers: *Lonchocarpus Blackii*, *Diploglottis Cunninghamii*, *Legnephora Moorei*, *Glochidion Ferdinandi*, *Alectryon subcinereus*, *Sideroxylon australe*, *Baloghia lucida*, *Guoia semiglauca*, *Myrtus Beckleri*, *Eugenia Smithii* and *Croton Verreauxii*. *Cedrela australis* is an important outlier species in the lower parts of the valley; *Duboisia myoporoides*, *Hymenosporum flavum*, and *Pittosporum undulatum* also occur.

(c) The Manning River Valley.

The main rain-forest of the upper Manning River and its tributaries was not investigated. Large outlier patches occur on the north-easterly-facing slopes of the enclosing mountain ranges (Pl. xiv, figs. 5, 6, of Part 1). Observations were made in these and in some isolated areas of rain-forest in sheltered parts of the main valley. These outliers occupy the slopes and beds of the creeks draining the slopes. The crests of the spurs between these creeks are occupied by Eucalypt forest. This type of outlier is illustrated in Plate xiii, fig. 52. Typically they are narrow towards the lower edge, and end where the creek meets the valley floor. They widen out in a fan-shaped fashion round the head of the creek, usually stopping abruptly below the crest of the main range. They are much less frequent and much smaller on the western-facing slopes, where they are present only in the deepest gullies. Small outliers are also present in the valley floor in sheltered and moist areas. Where they are in the undisturbed condition these areas of rain-forest appear to have the same structure as those of the Williams and Allyn River valleys. The general height of the taller trees appears to have been slightly greater than the average in the Williams River valley, approaching 100–120 feet.

A complete list of the rain-forest flora in this district was not made, but the important and conspicuous members of the lower rain-forest outliers are given in Table 6, column 2. *Cedrela australis* appeared to be especially common and in places was regenerating very rapidly after clearing (Pl. x, fig. 33).

Rain-Forest Outliers to the East and West of the Plateau.

Mountainous country continuous with the south-east part of the Barrington Tops Plateau occurs north and east of Dungog. Here deep sheltered gullies occur, but the rainfall is not adequate for the development of a luxuriant rain-forest. Small patches of a type of mixed formation are present here, in which some of the hardier rain-forest species are present. The structure of these outliers is

not so highly integrated as that of a mature rain-forest. Lianes are common, forming thickets, and there is a fairly high proportion of shrub species and Eucalypt-forest species. The canopy of the tree stratum may not be continuous. *Tristania conferta* appears to be the most important single species. Similar outliers occur in the mountains near Gloucester and further east, e.g., at Krambach Mountain (Maiden, 1895).

The rivers which drain the eastern part of the Barrington Tops after leaving their deep valleys flow through undulating hilly country. In this region there appears a typical river-bank flora which, because of its density and floristic composition, is obviously related to the sub-tropical rain-forest (Pl. xi, figs. 35, 36, 37). The chief species are: *Eugenia Ventenatii, Tristania laurina, Cissus* spp., *Cryptocarya glaucescens, Evodia micrococca, Clerodendron tomentosum, Pittosporum undulatum, Guoia semiglauca* and *Eugenia Smithii.*

Small outliers occur to the west of the Barrington Tops Plateau on slopes or sheltered areas where drainage collects. These lack the typical structure of rain-forest and consist of a relatively few tree and liane species. The most common are *Elaeodendron australe, Ficus stephanocarpa, Celastrus australis, Ehretia acuminata, Tecoma australis, Trema cannabina* and *Hymenosporum flavum.* Mixed with them are representatives of the western flora, e.g., *Geijera parvifolia, Canthium oleifolium, Notelaea microcarpa* and *Acacia salicina,* and of the Eucalypt-forest formation in which the outliers occur. The western species have been able to migrate eastwards by way of the Cassilis Geocol.

The Sub-Antarctic Rain-Forest (Beech Forest).

Distribution.

The sub-tropical rain-forest grades into the sub-antarctic rain-forest at 3,000–3,500 feet. The first sign of the change is the occurrence of isolated large trees of *Nothofagus Moorei,* the antarctic beech, amongst the typical species of the upper sub-tropical rain-forest. On sheltered slopes the transition zone is at about 3,500 feet, but on comparatively dry slopes it is 500 feet lower.

The same factor, exposure to the west, which limits the distribution of the sub-tropical rain-forest decides the boundaries of the sub-antarctic rain-forest. On the western side of the Williams Range the upper margin of the forest is 500–700 feet below that on the eastern side, where it approaches the top of the ridge. At or about 4,500 feet, the top of the ridge widens out and flat areas occur which are sheltered by the margin of the plateau from the west. These are occupied by sub-antarctic rain-forest. It extends upwards along beds of creeks and folds in the spurs to the plateau, and is present in a depauperated form along the plateau creeks. The maximum development of the forest takes place at 3,000–4,200 feet, where the trees attain their greatest size. As the upper limit of the forest is approached the heights of the trees decrease.

Composition.

The sub-antarctic rain-forest is essentially similar in composition in the upper Williams, Allyn and Barrington River valleys, and probably also in the valleys of the other rivers draining the plateau. It varies in detail from the lowest levels to the plateau. At the lowest levels there is a certain admixture of sub-tropical rain-forest species, and at the higher levels a number of species are present which are absent from the main part of the forest. In Table 7 a list is given of all the species which have been found forming part of the forest.

Structure.

Nothofagus Moorei is dominant throughout the forest, and, being the only large tree, gives the formation its typical appearance (Pl. xi, figs. 39, 41). This species is evergreen, with small, coriaceous leaves and rough bark, and attains a height of 150 feet and a diameter of 4 feet. It occurs with a frequency of about 2·4 per 100 square feet and appears to be evenly distributed. So conspicuous is it that this type of forest is commonly called beech forest.

Stratification is not so marked in the beech forest as in the sub-tropical rain-forest. The tall-tree layer, consisting of *Nothofagus* with its canopy extending to 150 feet, forms a continuous cover, but does not cut out as much light as the sub-tropical rain-forest trees. The canopy is very deep, the trees producing leafy branches upwards from 30 to 40 feet (Pl. xi, figs. 39, 41, 42). A discontinuous small-tree layer is present, varying in height up to 45 feet. The constituent species are *Doryphora sassafras*, *Elaeocarpus holopetalus*, *Quintinia Sieberi*, *Weinmannia rubifolia* and *Pittosporum undulatum*. Of these, the last three are found only below 4,000 feet. Above this altitude *Atherosperma moschatum* takes their place.

A discontinuous layer of shrubs is present in some places, the individual members of which are somewhat straggling. Important species are *Notelaea venosa*, *Drimys purpurascens*, *Citriobatus multiflorus*, *Hymenanthera dentata*, *Lomatia arborescens* and *Trochocarpa laurina*. These are most numerous along the margin and some are present in the adjoining Eucalypt forest. It is probable that they are mostly relics of former margins, or Eucalypt forest, as they do not seem to be specially suited to the shaded environment of the rain-forest.

There is a lower stratum of ferns forming a continuous cover in the lighter parts of the forest and especially in very wet areas. The commonest species is the tree-fern *Dicksonia antarctica* (Pl. xi, figs. 39, 40). *Dryopteris acuminata*, *Asplenium bulbiferum* and *Polystichum aculeatum* are also important. In the drier parts of the forest the ferns are scanty (Pl. xi, figs. 41, 42).

In the sub-tropical rain-forest one of the most conspicuous features is the presence of numerous sapling and seedling representatives of the tree species. This development is entirely lacking in the beech forest; saplings and seedlings are rare except around the margin of the forest.

In Table 8 the results are given of 17 quadrats taken at random in mature sub-antarctic rain-forest at 3,800–4,200 feet. It can be seen from Table 9, which summarizes the results, that the number of trees per unit area is smaller than in the lower forest, but that the relative proportion of large trees is greater.

Lianes are not common in the beech forest and rarely reach the upper levels of the canopy. The most frequently occurring species is *Smilax australis*, which is present at all levels. It is present on trees up to a height of about 60 feet, but more usually forms thorny thickets, which are almost impenetrable, on the lower shrubs and on the ground. Other species are *Streptothamnus Beckleri*, which forms thickets in light places, *Cissus* spp. and *Lyonsia Brownii*. Of these, *Cissus* is only found in the lowest parts of the forest, where it is most protected, and *Lyonsia* and *Streptothamnus* occur at an altitude of 4,000–4,500 feet, but are absent from the lowest parts of the forest.

The number of Angiosperm and Pteridophyte epiphytes, both from the point of view of the number of species and the total number of individuals, is very small compared with that found in the sub-tropical rain-forest. Mosses and lichens are in great abundance both on tree trunks (Pl. xi, fig. 41) and on exposed rock surfaces.

The Margins of the Sub-antarctic Rain-Forest.

The beech forest, like the sub-tropical rain-forest, is invading the adjoining formations on all sides, except where it is in contact with the sub-tropical rain-forest. This invasion is especially marked at the lower levels, where mature Eucalypt trees are frequently present (Pl. xi, fig. 41, left centre) together with the sub-antarctic species. No regeneration of Eucalypts in the beech forest was observed, and all the trees were mature, so that their presence is strong evidence of invasion. Old dead trunks of Eucalypts are also occasionally to be seen still standing in the deeper parts of the forest.

(*a*) *The Margin adjoining the Sub-tropical Rain-Forest.*

Where the lower margin merges into the sub-tropical rain-forest no advance seems to be taking place. The individual trees of *Nothofagus* which are present in the mixed forest are all very large and apparently of considerable age. The transition between the sub-tropical and the sub-antarctic rain-forests takes place in any one area over a vertical range of about 100 feet. Below this is rain-forest of typical sub-tropical structure and above it forest of typical sub-antarctic structure. The lower part of the sub-antarctic forest has, however, a small proportion of species which have obviously come up from lower levels. Chief among these are *Cissus* spp., *Quintinia Sieberi*, *Weinmannia rubifolia*, *Pittosporum undulatum* and *Doryphora sassafras*. All but *Doryphora* are present to an altitude of only 4,000 feet, and are comparatively rare even at lower levels. *Doryphora*, on the other hand, extends to 5,000 feet and is an important member of the forest. The liane *Smilax australis* is of greater importance in the sub-antarctic forest than in the sub-tropical forest.

(*b*) *The Margin adjoining the Eucalypt Forest.*

Where the sub-antarctic forest adjoins the lower Eucalypt forest advance is taking place, and young trees of *Nothofagus* are very common, often forming dense thickets. It is not uncommon to find isolated well-developed young trees in the Eucalypt forest at some distance from the actual margin. A number of shrub and small tree species characteristic of the marginal zone are: *Hymenosporum flavum*, *Hymenanthera dentata*, *Acacia melanoxylon*, *Tristania laurina*, *Hedycarya angustifolia*, *Lomatia arborescens*, *Tieghemopanax sambucifolius* and *Astrotricha floccosa*. *Smilax australis* is common, forming low thickets, and dense communities of the fern *Gleichenia flagellaris* are present in wet places at 3,500–4,000 feet.

The most rapid advance is taking place at 4,000–4,500 feet along flat parts of the ridges at the head-waters of creeks sheltered from the west. Where advance is especially rapid, isolated stands of *Nothofagus* are present in areas of suitable shelter and moisture well in advance of the general forest margin (Pl. xi, fig. 46). These all have the same composition and structure. Beech trees up to 70 feet in height are present in the centre, and around them progressively smaller trees, and finally a marginal zone in which some shrubs characteristic of the surrounding forest are present. The depth of the marginal zone and the number of small trees give a measure of the rapidity with which the forest is advancing. In all cases old Eucalypt trees are present throughout, together with occasional clumps of *Poa caespitosa* and *Lomandra longifolia*.

The margin of the main forest is composed of young trees of *Nothofagus* (Pl. xi, fig. 47), together with a number of characteristic shrubs, the commonest of which are: *Elaeocarpus holopetalus*, *Notelaea venosa*, *Lomatia arborescens*.

Doryphora sassafras, *Tieghemopanax sambucifolius*, *Drimys purpurascens*, *Trochocarpa laurina* and *Hedycarya angustifolia*. *Dicksonia antarctica*, *Polystichum aculeatum* and *Smilax australis* are present also. The tree-fern *Dicksonia* shows a similar relationship to the subantarctic forest as does *Alsophila australis* to the sub-tropical forest (Pl. xi, figs. 44, 45). It is present often with *Polystichum aculeatum* as a definite community around the margins, especially in damp places, but, unlike *Alsophila*, it is also common in the mature rain-forest, apparently because the light is not so greatly diminished as in the sub-tropical rain-forest.

Along the higher margins of the forest, advance is not so rapid. The following species form a true margin community corresponding to that of the lower rain-forest: *Prostanthera lasianthos*, *Leptospermum flavescens*, *Pimelea ligustrina*, and *Tieghemopanax sambucifolius*. *Dicksonia antarctica*, *Trochocarpa laurina* and *Elaeocarpus holopetalus* are usually present in this type of margin also.

(*c*) *The Creek Forest on the Plateau.*

A community comprising some sub-antarctic forest constituents is present along sheltered creeks on the plateau, and is continuous with the main forest into which it grades. The maximum height attained by the trees rarely exceeds 40 feet, and the forest is not very dense. The species usually present are: *Nothofagus Moorei*, *Atherosperma moschatum*, *Elaeocarpus holopetalus*, *Lomatia arborescens*, *Coprosma* spp., *Smilax australis*, *Helichrysum chrysophylla* and *Epacris* spp. Small stunted bushes of *Nothofagus* and *Trochocarpa* along the margins indicate that this community is advancing slowly. Many of the species found in this community are not naturally constituents of the rain-forest. Species of *Coprosma*, *Epacris* and *Helichrysum* form part of the true plateau flora.

Discussion and Conclusions.

Distribution.

Superficially tropical and sub-tropical rain-forests throughout the world have a similar appearance. The chief characteristics are the high, dense canopy, the laurel leaves with drip tips and pulvini, the buttressing of the lower trunks of the trees and, in extreme cases, the presence of prop and stilt roots, the presence of lianes, epiphytes and ferns, and the relatively less abundant shrubs. The numerous epiphytic mosses and lichens indicate a humid atmosphere.

The chief requirements for the development of the forest are a large amount of available moisture and a moderately high temperature. A humid atmosphere due to topographical causes is advantageous, but not absolutely essential, as once the forest is established it controls its own internal atmosphere to a large extent.

Raunkiaer (1934) has emphasized that the distribution of the rainfall is as important as its total amount, and Herbert (1935) has discussed this in relation to the Australian flora. It is evident, for example, that if the greatest amount of rain fell in the winter months and the hot months were dry, a rain-forest could not be supported. The rainfall received by the upper Williams River valley is not greatly in excess of that received by the parts of the Northern Territory described as carrying open forest, but which receive practically their whole rainfall during two or three summer months. In north-eastern New South Wales the rainfall is fairly well distributed, but a rather greater amount is received in the hottest months, so that during this period the atmosphere of the rain-forests is humid, provided that they are protected from the only desiccating wind, the westerly.

On the east coast of New South Wales, where the annual rainfall varies from 3,000–6,000 points, the nature of the soil is a deciding factor in the distribution

of rain-forest, a soil of high water-retaining capacity being essential for its development at this rainfall. The same rainfall which, on the Hawkesbury sandstone near Sydney, is only sufficient to permit the development of Eucalypt forest or scrub, may, on a soil of higher water-retaining capacity, be adequate to support the growth of rain-forest. This control of vegetation by soil type is especially well shown on the Comboyne Plateau, where the average rainfall is 6,500 points p.a. Adjacent siliceous and basalt soils support respectively sclerophyll forest and luxuriant rain-forest. The same type of distribution can be seen at Dorrigo and at Robertson.

The soil derived from all types of rocks present in the area studied appears to be sufficiently good to support the most luxuriant type of vegetation, namely rain-forest, the characters of a good soil being assumed to be high water-retaining capacity, adequate drainage, and an adequate supply of mineral salts and humus. The water-retaining capacity is markedly high in all the soil types examined. As might be expected, soil from the beech forest shows the highest humus content, the lower temperatures prevailing at the altitude at which it occurs being less favourable for the rapid decay and complete destruction of plant remains.

The high and evenly distributed rainfall, combined with a soil of high water-retaining capacity, means that the water supply alone is not a limiting factor in the distribution of communities, except in areas which are especially exposed to evaporation or excessive drainage.

In the area studied, the upper limits of the sub-tropical rain-forest seem to be determined by winter temperature, as it ceases, even in the most favoured localities, at the height at which snow is experienced. The occurrence of frosts may also have a controlling influence at lower altitudes. Frosts do not form beneath the canopies of the lower Eucalypt forest or sub-tropical rain-forest, but they occur in the cleared areas below them. It is probable that the presence of a canopy, by decreasing evaporation, prevents the lowering of the temperature to the necessary extent for frost formation at the lower altitudes, but above 3,000 feet frosts form regularly in winter beneath the canopy of the Eucalypt forest and in the more open parts of the sub-antarctic rain-forest. This must prevent the establishment of seedlings of rain-forest species and consequently the advance of the sub-tropical rain-forest into the Eucalypt forest. A few members of the sub-tropical rain-forest, which are able to withstand a degree of cold, are found in the lower part of the beech forest. It is therefore evident that the beech forest affords more protection than the adjoining Eucalypt-forest formation.

Temperature is probably responsible for the relative poverty of species in the upper parts of the sub-tropical rain-forest. Temperature is also apparently responsible for the few epiphytes other than mosses and lichens to be found in the beech forest, as the conditions of humidity are very favourable.

The west-facing slopes are colonized by rain-forest to a less extent than those sheltered from the west. The question arises therefore whether it is insolation or the effects of the westerly winds which are of importance in determining this effect. Though this would have to be determined by experiment, since in the field no areas were observed which received maximum sunlight and did not also receive considerable wind action, a reduction in the amount of sunlight does not appear to make any significant difference to the composition and structure of the upper layers of the forest, and at most means a slight diminution in the amount of the ground flora. It is therefore probable that the action of the wind

in drying the soil and increasing transpiration is the chief factor controlling the distribution of the rain-forests below 3,000 feet.

Above 3,000 feet the rainfall appears to be such that the soil, even in the Eucalypt forest, is always moist to wet, but even at this altitude the sub-antarctic rain-forest is not developed on west-facing slopes. It appears most likely that this is due to wind action and temperature. Strong snow-laden winds sweep over the edge of the plateau and beat on the west-facing slopes, while the sheltered gullies, though receiving an equal amount of snow, escape the direct action of the wind.

In the area studied in detail, the dip of the rock appears to have no effect on the distribution of the rain-forest. In some places, however, along the lower Gloucester and Manning Rivers rain-forest species occur growing on rather exposed hillsides, and the explanation appears to be that the dip of the rocks causes continual seepage at those points (Pl. xii, fig. 51).

Structure.

The sub-tropical rain-forests of New South Wales resemble in structure those described by Richards (1936) for North Borneo, though they lack their luxuriance. All the important characters noted by Richards, of which the absence of special dominants is the chief, are present. This is in distinction to the Guiana rain-forests described by Davis and Richards (1933), in parts of which dominants definitely occur. They found that the highest type of rain-forest in Guiana developed on the best soil, and that in this forest no special dominants could be detected. On poorer soils, however, a less highly integrated forest with a greater degree of dominance of single species developed. No comparable condition exists in the Williams River valley, where no poor soil types are present.

At Mount Dulit (North Borneo), Richards (1936) found that, of 98 species, each constituted no more than 5% of the total number of plants. Of the 181 trees over 30 feet in height, belonging to 34 different species, which occur in the quadrat areas examined in the Williams River rain-forest, only one species (*Schizomeria ovata*) accounts for more than 10%, and three others (*Doryphora sassafras*, *Ackama Muelleri* and *Cryptocarya glaucescens*) for slightly less. The remaining 30 species each account for 5% or less. Twelve species each occur only once in the areas examined. In the sub-antarctic rain-forest, on the other hand, *Nothofagus Moorei* constitutes 76% of the trees over 30 feet in height.

The Williams River rain-forest is relatively simple when compared with tropical forests, because of the comparatively few species and the rather homogeneous habitat.

In North Borneo, Richards has distinguished two sets of tree species, one mature at 60 feet and another at 25 feet. A rather similar division can be made in the rain-forests of the Williams River. A few species, such as *Diospyros Cargillia*, *Croton Verreauxii* and *Evodia micrococca*, form a class of small trees, rarely attaining a height greater than 30 feet. The remainder attain a height of over 60 feet.

Epiphytes are of great importance in tropical rain-forests throughout the world. Thirty-nine species of epiphytic ferns and phanerogams are present in the sub-tropical rain-forest of the Williams River valley.

In his analysis of the epiphytes of the New Zealand rain-forests, Oliver (1930) found that a large class, to which he referred as "ephemerals", might be either

epiphytic or terrestrial. This "ephemeral" epiphytic class is scarcely represented in the Williams River rain-forest. Only one species, the fern *Hymenophyllum tunbridgense*, which is common on the ground and on rocks, is also found sometimes at low levels on tree trunks. The strangler fig (*Ficus Henneana*) usually starts life as an epiphyte, but very rarely may also behave as a terrestrial species. The climbing ferns such as *Pleopeltis pustulata* and *Arthropteris tenella* are always connected to the earth by long rhizomes, and if these are severed the upper parts die; but Oliver notes that the same species in New Zealand may behave as true epiphytes and have no connection with the ground. Oliver also records *Asplenium bulbiferum* as a true epiphyte, but in the Williams River rain-forest it seems to be exclusively terrestrial. The development of an ephemeral epiphyte class in New Zealand rain-forests is probably due to the greater degree of moisture obtaining there.

Composition and Comparison with other Rain-Forest Areas in New South Wales.

The results obtained from the quadrat analyses are not considered to give a complete picture of the relative abundance of all the species in the sub-tropical rain-forest. Many species which were not recorded at all in the quadrat areas are locally abundant in other parts of the forest which were not analysed in this way. Field observations have shown, however, that the four most important species in the quadrats, *Schizomeria ovata*, *Ackama Muelleri*, *Doryphora sassafras* and *Cryptocarya glaucescens*, are common and relatively abundant throughout the forest, though more numerous in some places than in others. A point brought out to a certain extent is the relative abundance of some species in one area and their absence from another.

Table 2 shows the very high percentage of saplings and seedlings. Many of the saplings may attain a height of 30 feet or more, with a diameter of 2 to 3 inches and a crown of a few dozen leaves. They probably remain in much the same condition for years. Many of them never reach the canopy, and may die even after reaching the 30 feet stage.

The percentage of seedlings belonging to some species is abnormally high, whilst other species common in the tree stratum, e.g. *Schizomeria ovata* and *Doryphora sassafras*, are uncommon as seedlings. This is probably due to the season, some species having flowered and set numerous seeds while others have not flowered at all. This is not unusual in the sub-tropical rain-forest where many species flower very sporadically, while others, notably *Polyosma Cunninghamii*, always seem to have a few flowers present. Table 2 emphasizes the absence of *Eucalyptus* and *Syncarpia* seedlings.

It is a well-known fact that isolated rain-forest trees often flower more freely and regularly than those in the rain-forest, and this is probably related to the greater amount of light which they receive. Many flower in the shrub stage, e.g. *Synoum glandulosum*, *Cryptocarya microneura*, *C. patentinervis* and *Litsea dealbata*.

It is concluded that the major features of species distribution within the sub-tropical rain-forest are due to chance, i.e. the development of seeds during a good season, and the presence of seedlings able to take advantage of such favourable circumstances as accidental light breaks. All the most important species of trees occur throughout the whole forest, and their local abundance cannot be related to any constant feature of the environment, nor does a group of species occur constantly associated over any type of area. The distribution of individual species appears to be quite independent. This further supports the conclusion

that the distribution is not simply a matter of the environment, for the environment cannot show sufficient changes to account for all the groupings of species which occur. This distribution was born out by the seedlings found. In places one species would be very common, in other places entirely absent, due perhaps to distribution of the seeds by birds or animals.

It follows that the differences between the floras of different and unconnected valleys may be due to the operation of the factor of chance on a larger scale.

A striking feature of the sub-antarctic rain-forest when compared with the sub-tropical rain-forest is the relatively small number of saplings of *Nothofagus Moorei*. The ability to grow under conditions of dense shade appears to be a characteristic of sub-tropical rain-forest species which is not shared by *Nothofagus*.

Interference has been so relatively slight in the rain-forest of the upper Williams River valley that the observations made on regeneration give a picture only of the re-establishment of the complex forest structure directly from existing stock. The sequence of events which follows complete destruction over large areas cannot be traced here. During the early timber-getting operations, the species which suffered most severely was *Cedrela australis*. Very few trees of this species remain, especially in the lower part of the rain-forest, and regeneration does not appear to be going on to any extent. This is noteworthy, as regeneration of cedar is taking place, noticeably in parts of the Allyn, Chichester and Manning River valleys, and is most marked in areas which have been partially cleared. In these parts, where parent trees are present, dense stands of strong growing cedar saplings occur (Pl. x, fig. 33).

It is possible that the relative absence of regeneration of cedar in the Williams River valley may be due as much to the relatively slight amount of disturbance as to the clearing of most parent trees, as the cedar is a prolific producer of winged seeds, which are easily transported by wind. Observations suggest that regeneration of this species is especially favoured by disturbance of the soil and breaks which allow a maximum of light to reach the ground.

Though the largest trees of rosewood (*Dysoxylum Fraseranum*) have been removed, seedlings and saplings of this species are common throughout the forest and are especially abundant in the upper parts of the sub-tropical rain-forest.

Ecological Relationships.

(*a*) *Sub-tropical Rain-Forest.*

Ecologically the sub-tropical rain-forest formation of eastern Australia, to which the Williams River rain-forest belongs, is a homogeneous formation, each species being subordinate to the general structure of the whole. Because of their obvious differences from all other types of flora, the sub-tropical rain-forest and the sub-antarctic rain-forest may each be considered as formations in the sense used by Clements (1916). The amount of variation within the sub-tropical rain-forest is so great that treatment by the conventional methods applied to forest communities is not practicable. It can be seen from a comparison of Tables 2, 3 and 4 that local abundance of an upper stratum species is never linked with a particular type of ground flora, or with a particular group of associated species in the shrub or tree strata.

Until detailed accounts of the structure of the remaining areas of rain-forest in New South Wales and Queensland are available, it would be premature to decide what constitutes an association within this formation, or whether indeed any grouping of rain-forest trees of the order of an association exists. Most of the separate areas of rain-forest in New South Wales are different in details of

composition, and it is possible that the smaller ones may each be considered to belong to the grade of an association. In the larger, more northerly sub-tropical rain-forests a certain amount of variation occurs. Jolly (1928) mentions the importance of the Hoop Pine (*Araucaria Cunninghamii*) in the extreme north of New South Wales and of *Ceratopetalum apetalum* at Dorrigo, where in places it forms nearly pure forests. In Queensland several sub-types of rain-forests are recognized, characterized by different species, and Swain (1928, p. 37) describes a number of regions of rain-forest based on thermal range. This suggests that some rain-forest areas may consist of several associations.

The sub-tropical rain-forests of the Williams River valley may perhaps best be regarded as a mixed association, showing a greater tendency to local abundance of species than was found for a tropical rain-forest in north Borneo by Richards (1936), but much less than was found by Brough, McLuckie and Petrie (1924) for an area of impure sub-tropical rain-forest at Mt. Wilson, N.S.W. It is very probable that a detailed study of a more extensive area of rain-forest which comprises more variety of topography and soil, would yield slightly different results, more especially in the marginal parts of the forest. It is considered, however, that the mixed structure here described is characteristic of the sub-tropical rain-forest of the coast of eastern New South Wales.

The sub-tropical rain-forest of the Williams River district represents a fusion of two formations, of which one, the true sub-tropical rain-forest, has given the character to the whole and determined its ecological position. The subordinate formation is the Eucalypt-forest formation which the rain-forest is still in the process of invading. The little that remains of this consists of the two species *Eucalyptus saligna* and *Syncarpia laurifolia*, which are able to regenerate and maintain themselves independently from, and probably without influencing, the rain-forest. No other important species are common to the Eucalypt-forest formation and the rain-forest.

The variation in composition of the mature forest from place to place appears to be due to chance. Aspect is of minor importance, its influence being shown by the local presence of small communities such as those of water-loving plants in a soakage area, or on a river bank. No true consociation can be recognized. Of the water-loving species the following appear to be able to flourish in the shaded conditions of the mature forest: *Callicoma serratifolia*, *Tristania laurina*, *Laportea gigas* and *Alectryon subcinereus*. *Backhousia myrtifolia* and *Weinmannia rubifolia* are never found in the closed forest and appear to be obligate light species.

Apart from the water- and light-loving communities the only other species which show a selective choice of habitat are the obligate margin species *Trochocarpa laurina*, *Commerconia echinata*, *Hibiscus heterophyllus* and *Solanum stelligerum*.

The sub-tropical rain-forest appears to be fairly highly integrated. If a break occurs in the canopy a great development of ferns takes place. Herbs are not numerous, being scanty in the forest itself. Herbs and shrubs play a large part in the regeneration of partly denuded areas, and these are killed out by lack of light as the break regenerates to mature forest.

(*b*) *Sub-antarctic Rain-Forest.*

Ecologically and floristically the sub-antarctic rain-forest is related to the great system of rain-forests characteristic of the moist, high latitudes of the southern hemisphere, and of high altitudes in the warmer regions. In New South Wales the sub-antarctic rain-forest formation is less continuous and smaller than

the sub-tropical rain-forest, and varies greatly from place to place in floristic composition, though probably no more so than does the sub-tropical rain-forest. Its chief characteristics are the dominance of a few species, the relatively small total number of species when compared with the sub-tropical rain-forest, and the relative paucity of lianes and epiphytic ferns and phanerogams. Mosses and lichens are abundant.

These features mark it off at once from the sub-tropical rain-forest as a different formation, especially in view of the fact that floristically also it is a fairly homogeneous unit.

More work is necessary before it can be determined what associations occur. At present the Williams River sub-antarctic rain-forest is regarded as a distinct association dominated by *Nothofagus Moorei* and *Doryphora sassafras.*

The chief characteristic of the sub-antarctic rain-forest in New South Wales is the importance of the single species *Nothofagus Moorei.* This species does not occur in Victoria or Tasmania, where it is replaced by *Nothofagus Cunninghamii.*

Besides those of the Williams River valley, the only other considerable forests of beech in New South Wales are those of Dorrigo, and the MacPherson Ranges on the Queensland border. The Dorrigo forests have been largely destroyed, but it is evident that in their natural state they did not represent such a pure condition as those of the Williams River valley. They occur on the higher parts of the plateau, but, being further north and the highest altitude being only 3,000 feet, they grow under warmer conditions, and are strongly mixed with sub-tropical species, which seem to have given the forest a tropical rather than a temperate appearance, though many of the typical beech-forest species are present.

The MacPherson Range beech forest described by Herbert (1936) appears to show a condition intermediate between the Dorrigo and Williams River forests. It has the typical appearance of the sub-antarctic forest, but in addition has many species which are intrusive from the sub-tropical forest. It has been reported as advancing over adjacent Eucalypt forest in the same manner as the formation does at Barrington Tops.

Herbert (1935) distinguishes two types of formation in the cold parts of Tasmania, the beech forests which occur in regions of shelter and moisture, and the sub-alpine and alpine vegetation of the exposed areas which is predominantly low. Though a pure sub-alpine flora does not occur on the Barrington Tops Plateau, because the conditions of cold and exposure are not sufficiently extreme, a number of individual sub-alpine species are present. These will be discussed in a later section.

Distribution of Species.

(*a*) *Sub-tropical Rain-Forest.*

The Williams River rain-forest is isolated from the eastern and southern areas of rain-forest by a zone of low rainfall, and from the north by mountain ranges in which discontinuous areas of rain-forest occur. It is therefore to be expected that it will be poorer in species than the northern and eastern rain-forest areas. There is a significant absence from the Williams River valley of many species common in the Manning River rain-forests. The most important are marked * in Table 6.

In the list of the Comboyne flora given by Chisholm (1934 and 1937) 37 species are recorded (see Table 10, column 1) which are not present in the Williams River valley, while only 7 occur in the Williams River valley which are not represented there, including *Polystichum aristatum, Malaisia tortuosa, Tetrastigma nitens, Elaeocarpus obovatus, Scolopia Brownii* and *Coelospermum paniculatum.*

At Dorrigo, which is further north than Comboyne, Maiden (1894) has recorded 36 species which have not been found in the Williams River valley, some of which are also absent from Comboyne (see Table 10, column 2).

A number of species recorded by Maiden (1895 and 1898) from Port Macquarie, Krambach and the upper Hastings River (Table 10, columns 3, 4, 5) are not represented in the Williams River valley.

It is apparent, therefore, that temperature probably restricts the distribution of many species occurring on the northern part of the coast. A number of species present along the coast to south of the Hunter River have not been able to migrate westward and colonize the Williams River area. It is probable that the dry zone between the coast and the highlands has formed an effective barrier. Most noticeable of these species are *Livistona australis*, *Archontophoenix Cunninghamiana*, *Flagellaria indica*, *Ceratopetalum apetalum* and *Fieldia australis*.

The most important absence is that of *Ceratopetalum apetalum*, a common member of the rain-forests of Comboyne, Dorrigo, Bulga, the MacPherson Ranges and the south coast. This tree in places forms dense communities, especially in the poorer or marginal part of the forest. It can only be suggested that its absence is due to the distance west of the forest areas and the lack of suitable methods of seed dissemination.

A type of occurrence which may throw some light on the problems of the distribution is shown by *Tristania conferta*, *Aphananthe philippinensis*, *Mallotus philippinensis*, *Legnephora Moorei* and *Lonchocarpus Blackii*. The case of *Tristania conferta* is most outstanding. This species appears to be able to develop only in fairly light situations. In the northern rain-forests of Dorrigo and Bulga it is absent from the densest parts, but is present along some margins, in places forming almost pure stands. It is also present in gullies and on sheltered hillsides from which rain-forest is absent. It is probably not a true rain-forest species, but requires similar conditions of moisture and shelter to those required by rain-forest species. It apparently also requires light for its best development. In the Barrington Tops area it can therefore be regarded as a light-loving species invading the area later than the majority of rain-forest species, and therefore finding little suitable ground for colonization. It is noticeable that in the Williams River valley it is restricted to the lower creeks, where the rain-forest is young, that it is absent from the Allyn valley, and that it is relatively abundant in the Chichester valley. It is apparently absent also from the Manning River, though common near Gloucester and Dungog. This suggests that it has invaded the district by way of outliers to the north-east, and has found more suitable uncolonized ground in the Chichester River valley, having arrived there at an earlier stage of invasion than in the Williams valley. The other species occurring only in the lower outliers of the Williams River valley, i.e. *Mallotus philippinensis*, *Legnephora Moorei* and *Lonchocarpus Blackii*, and in the Allyn valley, *Aphananthe philippinensis*, may similarly be late colonists from other rain-forest areas which are unable to, or have not yet been able to, invade the main forest.

(b) Sub-antarctic Rain-Forest.

Nothofagus Moorei is here at its southernmost limit, and *Atherosperma moschatum* and *Elaeocarpus holopetalus* at their northernmost limit. *Streptothamnus Beckleri* appears to be a montane rather than a sub-antarctic species; it occurs also at Dorrigo associated with *Nothofagus*.

Although the two rain-forest formations overlap in space, and certain species of the one are present throughout the other, e.g. *Doryphora sassafras*, they are unrelated floristically, ecologically and structurally. In all probability in this area

they were unconnected in the past, the sub-tropical forest occupying the lower floors, and the sub-antarctic forest the upper parts of the valley, and their present contiguity is due to the advance upward of the sub-tropical rain-forest and to a lesser extent downward of the sub-antarctic. For if the upward extent of the sub-tropical rain-forest is finally checked by low temperature, the downward extent of the sub-antarctic forest is probably stopped by high temperature. Whether the beech was present in the original rain-forest of Tertiary times or whether it is a more recent invader following the suitable conditions brought about by the orogenic movements of the late Tertiary cannot here be decided.

The small restricted outliers near Nundle and Moonan Flat may perhaps be regarded as relics of a more extensive forest.

All the isolated areas of rain-forest along the margins of the eastern coast of New South Wales differ in details of composition, but it is probable that they preserve throughout the structure which has been found typical in the Williams River district. It has yet to be determined how much of this variation is due to the factors of the environment, such as water supply, soil, aspect and temperature, and how much is due to chance migration, the inability of a new species to become established in a mature forest, and individual preferences due to soil composition.

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DESCRIPTION OF PLATES VII-XIII.

Plate vii.

1.—Fairly dense sub-tropical rain-forest showing spacing of the trees, relative paucity of the ground flora, and lianes hanging from the trees at the right.

2.—A community of *Alsophila Leichhardtiana* and small ferns on a moist hillside. The tree trunks are those of *Endiandra discolor* and *Gmelina Leichhardtii.*

3.—*Eucalyptus saligna* trees at the lower margin of the sub-tropical rain-forest.

4.—Sub-tropical rain-forest on the south-eastern slope of a hill in the Chichester River valley (1,000 feet altitude) showing *Eucalyptus saligna* trees extending above the level of the rain-forest canopy.

5.—Dense, comparatively young, sub-tropical rain-forest, showing thin tree trunks and lack of undergrowth; an old *Eucalyptus saligna* tree on the left.

6.—A light break in the sub-tropical rain-forest, showing the large number of lianes and ground-flora species present and the canopy extending to a low level.

7.—A light break in dense sub-tropical rain-forest. Note the clumps of *Gahnia* and young shrubs in the foreground and *Syncarpia laurifolia* and *Eucalyptus saligna* trees projecting above the canopy of the rain-forest in the background. Lianes are present on *Syncarpia.*

8.—*Pollia crispata* and ferns in a light break within the sub-tropical rain-forest. The moss *Papillaria* hangs from the branches of the tree at the left.

9.—A light break in the sub-tropical rain-forest, showing the development of liane thickets and communities of *Dennstaedtia davallioides* and *Colocasia macrorrhiza* in moist places.

Plate viii.

10.—Regeneration after removal of the sub-tropical rain-forest cover. Herbs, grasses, ferns and young shrubs become dominant around the margins.

11.—Thickets of young *Eucalyptus saligna* trees regenerating after partial clearing.

12.—Young *Eucalyptus saligna*, ferns and *Gahnia* in a light break in the sub-tropical rain-forest; a *Syncarpia laurifolia* tree occurs on the left.

13.—River bank showing the rain-forest canopy extending to the ground level, with an abundance of lianes completely covering the trees at the left, and *Eucalyptus saligna* extending well above the general level of the canopy.

14.—River bank showing an abundance of lianes covering the trees down to the water level.

15.—Sub-tropical rain-forest along the river at 1,000 feet altitude, showing the development of *Dicksonia antarctica* and *Lomandra Hystrix* in open, light areas.

16.—A small creek through dense sub-tropical rain-forest, showing scanty development of ground flora, mostly ferns.

17.—A small creek through dense sub-tropical rain-forest, showing the scanty development of ground flora owing to the unbroken canopy overhead. Fairly dense patches of tall shrubs occur, and *Elatostemma reticulatum* and a dense covering of moss on a fallen log are present on the left.

Plate ix.

18.—A relatively static sub-tropical rain-forest margin along a gully in a northerly-facing hillside. Tall *Eucalyptus saligna* trees can be seen towering above the level of the rain-forest in the creek. *Alsophila australis* and *Ackama Muelleri* are present in the rain-forest margin. *Eucalyptus saligna–Syncarpia laurifolia* forest with *Poa, Lomandra* and *Pteridium* occurs outside the rain-forest.

19.—A community of *Alsophila australis* in a damp, sheltered part of the *Eucalyptus saligna* forest. A pioneer tree of *Ackama Muelleri* from the rain-forest can be seen in the background.

20.—Margin of the sub-tropical rain-forest, fringing a creek on a north-easterly facing slope of the Williams Range (at 1,700 feet altitude), in contact with the *Eucalyptus acmenioides–E. campanulata* forest with *Imperata, Poa, Lomandra* and *Pteridium.* A border community of *Alsophila australis* and *E. saligna* occurs in the rain-forest margin.

21.—A typical, lower sub-tropical rain-forest showing some established trees about 25-30 feet high (*Rhodamnia trinervia* in the centre front), and young trees 1-2 feet high (about 1,000 feet altitude).

22.—A dense community of *Acronychia laevis* and *Rhodomyrtus psidioides* invading *Eucalyptus saligna* forest in the valley floor (about 1,000 feet altitude).

23.—Advancing margin of the sub-tropical rain-forest showing dense thickets of young *Schizomeria ovata* and *Callicoma serratifolia* trees, with *Dryopteris decomposita* forming the ground flora.

24.—A fairly dense community of saplings of *Daphnandra micrantha* and *Cryptocarya patentinervis* intrusive into the *Eucalyptus saligna* forest (note the large tree of *E. saligna* in the background), showing sparsity of the ground flora.

25.—Sub-tropical rain-forest margin advancing into the *Eucalyptus saligna* forest.

Plate x.

26.—Young rain-forest species and well-established trees of *Ackama Muelleri* colonizing a sheltered slope occupied by *Eucalyptus campanulata* and *E. saligna* forest, with a ground flora of *Culcita dubia.*

27.—*Eucalyptus campanulata–Casuarina torulosa* forest in process of invasion by rain-forest species (visible in the background and at right), with ground flora of *Lomandra longifolia.*

28.—A sub-tropical rain-forest margin, consisting of a thicket of *Callicoma serratifolia* with a tall tree of *Ackama Muelleri* on the left, advancing into the *Syncarpia laurifolia–Tristania conferta* forest; ground flora consists of *Imperata, Pteridium* and *Hibbertia* (Chichester River valley); *Syncarpia* and *Tristania* trees can be seen on the right.

29.—A sub-tropical rain-forest margin, showing heavy development of liane species, in contact with *Syncarpia laurifolia–Eucalyptus saligna* forest with some *Casuarina torulosa*; ground flora of *Imperata, Pteridium* and *Poa.*

30.—*Eucalyptus saligna* regenerating along the lower cleared margin of the sub-tropical rain-forest.

31.—A thicket of *Callistemon salignus* trees outside the lower limit of the sub-tropical rain-forest.

32.—*Colocasia macrorrhiza* and *Callistemon salignus* regenerating in cleared wet areas outside the limit of the rain-forest.

33.—Dense thicket of *Cedrela australis* regenerating in partly cleared rain-forest (Manning River valley, Coneac district).

34.—Regeneration of sub-tropical rain-forest in a gully in a cleared hillside facing south-west (Manning River valley).

Plate xi.

35.—Lianes and rain-forest trees along the river bank, with *Eucalyptus saligna* forest in the background (Chichester River valley).

36.—Outlier trees of *Eugenia Ventenatii, Cryptocarya glaucescens* and *Cedrela australis* along a river bank near Dungog.

37.—Communities of sub-tropical rain-forest trees fringing the Karuah River near Stroud, in pasture country.

38.—A typical, mixed sub-tropical rain-forest community at an altitude of about 3,200 feet on the Williams Range. The tree in the centre front is *Orites excelsa,* and *Pteris umbrosa* is conspicuous in the ground flora at the left; note also the shallow tree-roots in the centre foreground.

39.—The sub-antarctic rain-forest at an altitude of about 3,800 to 4,000 feet, showing *Nothofagus Moorei* and *Dicksonia antarctica.*

40.—A stand of *Dicksonia antarctica* in the *Nothofagus Moorei* (antarctic beech) forest, at an altitude of about 4,000 to 4,500 feet.

41.—A relatively mature *Nothofagus Moorei* forest at an altitude of about 4,200 feet, showing the low canopy extending almost to the ground, and the absence of a ground flora except for a few ferns. A tree of *Eucalyptus fastigata* can be seen in the background on the left.

42.—A comparatively young *Nothofagus Moorei* forest showing the deep canopy, the absence or sparsity of the ground flora, and the accumulation of litter.

43.—Beech forest intrusive into Eucalypt forest. *Eucalyptus viminalis* can be seen on the right and in the background, with young *Nothofagus Moorei, Poa* and *Lomandra* in the foreground. Note the litter accumulated under the *E. viminalis* trees. (Altitude about 4,000 feet.)

Plate xii.

44.—Young beech-forest occupying the head of a sheltered creek facing north-east on the Williams Range, at an altitude of 3,900 feet, showing the tree-fern *Dicksonia antarctica* partly enclosed by the *Nothofagus Moorei* community. The foreground and left show the *Eucalyptus obliqua–E. viminalis* forest, with a ground flora of *Poa, Lomandra* and *Senecio.*

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45.—Margin of a beech forest occupying a moist area in the sheltered head of a gully on the western side of the Williams Range, at an altitude of about 3,900 feet. In the background can be seen young *Nothofagus Moorei* trees, with *Alsophila australis* and *Dicksonia antarctica*, and in the foreground *Eucalyptus obliqua* and *E. viminalis*. Note the dense ground cover of *Poa* and *Lomandra* in the Eucalypt forest, the steepness of the slope, and the masses of *Macromitrium* on dead flakes of bark of *E. viminalis*.

46.—Beech forest intrusive into *Eucalyptus pauciflora–E. fastigata* forest at 4,800 feet (*E. pauciflora* centre, *E. fastigata* left). Ground flora of *Poa, Lomandra, Pteridium*, and a small plant of *Lomatia arborescens* in the right foreground.

47.—Young *Nothofagus Moorei* advancing into *Eucalyptus pauciflora* forest at 4,800 feet.

48.—River-bank community of *Gleichenia flabellata, Blechnum discolor* and *Lomandra longifolia* (Chichester River valley).

49.—*Tristania conferta* trees (about 160 feet high) occurring in rather open rain-forest (Chichester River).

50.—Outliers of sub-tropical rain-forest species growing in a soakage area at the base of a hill (Williams River valley, altitude about 900 feet).

51.—Outlier species (lianes and *Daphnandra micrantha*) occurring in a soakage area on hillsides in partly cleared Eucalypt forest (Manning River valley, near Coneac).

Plate xiii.

52.—Sub-tropical rain-forest occurring in a gully on a north-easterly-facing hillside in the Manning River valley near Coneac. This photograph shows the spreading of the upper margin of the rain-forest and its abrupt cessation just below the top of the hill.

53.—*Dysoxylum Fraseranum* showing the buttressing of the lower part of the trunk. Note the typical thin trunk of *Alsophila Leichhardtiana* in the foreground, and the stems of some lianes lying horizontally at the base of the tree.

54.—*Diospyros pentamera* in dense rain-forest, showing the shallow nature of the root system and the furrowing of the trunk between the roots.

55.—*Eucalyptus saligna* in rain-forest, showing development of Bryophyte colonies on the base of the trunk. Numerous lianes and the epiphytic bird's-nest fern (*Asplenium nidus*) can be seen.

56.—Typical sub-tropical rain-forest showing the shrub stratum, including *Citriobatus multiflorus* and *Psychotria loniceroides*, numerous lianes, and some epiphytic ferns such as *Asplenium nidus* and *Pleopeltis Brownii*.

57.—*Dawsonia superba* occurring on a shaded bank, illustrative of the dense carpets sometimes formed by the moss constituents of the ground flora.

58.—A tree trunk heavily covered with epiphytes, chiefly *Pleopeltis Brownii*, also young *Asplenium nidus* and orchids.

59.—*Ficus Henneana* showing aerial roots enveloping the "host" tree and the development of incipient buttresses.

60.—*Sloanea australis* showing slight buttressing of the lower part of the trunk.

TABLE 1.

List of Species occurring in the Sub-Tropical Rain-Forest and Rain-Forest Margins of the Williams River Valley.

Life Forms classed according to Raunkiaer (1934). R, rare ; S, scanty ; F, frequent ; LC, locally common ; C, common ; VC, very common ; LVC, locally very common.

Species.	Life-form.	Main Rain-forest.	Rain-forest Margin.	Species.	Life-form.	Main Rain-forest.	Rain-forest Margin.
Pteridophyta.				Polypodiaceae.			
Hymenophyllaceae.				*Adiantum aethiopicum* L. ..	H		S
Hymenophyllum tunbridgense Sm.	Ch	LC		*affine* Willd.	H	C	
Trichomanes caudatum Brack.	E	S		*diaphanum* Bl.	H	LC	R
Cyatheaceae.				*formosum* R.Br.	H	C	
Alsophila australis R.Br. ..	N		LC	*hispidulum* Sw.	H	C	
Leichhardtiana F.v.M. ..	M	LC		*Arthropteris Beckleri* Mett. ..	N	LC	
Dicksonia antarctica Labill. ..	N		R	*tenella* J.Sm.	N	C	

TABLE 1.—*Continued.*

Species.	Life-form.	Main Rain-forest.	Rain-forest Margin.
Asplenium adiantoides C.Chr.	E	C	
bulbiferum Forst.	H	LC	
nidus L.	E	C	
Athyrium umbrosum Presl. ..	H	LC	
Blechnum capense Schlecht. ..	H	LC	
cartilagineum Sw.	H-Ch	C	
Patersoni Mett.	H	LC	
Culcita dubia Maxon	H		VC
Cyclophorus confluens C.Chr. ..	E	C	
serpens C.Chr.	E	C	LC
Davallia pyxidata Cav. ..	E	C	
Dennstaedtia davallioides Moore	H	LC	
Diplazium japonicum Beddome	H	LC	LC
Doodia aspera R.Br.	H-Ch	LC	
caudata R.Br.	H-Ch		R
Dryopteris acuminata Watts ..	H-Ch	LC	LC
decomposita O. Kuntze ..	H	VC	
parasitica O. Kuntze ..	H	S	
Histiopteris incisa J.Sm. ..	H	LC	
Hypolepis punctata Mett. ..	H		LC
tenuifolia Bernh.	H	LC	LC
Pellaea falcata Fée	H	C	
Platycerium bifurcatum C.Chr.	E	VC	
Pleopeltis Brownii Fourn. ..	E	C	
diversifolia Melvaine ..	N	R	
pustulata Moore	N	C	
Polypodium Billardieri C.Chr.	H	R	
Polystichum aculeatum Schott.	H	F	
aristatum Presl.	H	R	
Pteris comans Forst.	H	R	
tremula R.Br.	H	S	
umbrosa R.Br.	H	LC	
Angiosperms.			
Monocotyledons.			
Gramineae.			
Microlaena stipoides R.Br. ..	H-Ch		F
Oplismenus aemulus Kunth. ..	Ch		R
imbecillus Kunth.	Ch		F
Panicum lachnophyllum R.Br.	Ch		R
pygmaeum R.Br.	Ch		LC
Poa caespitosa G.Forst. ..	H		C
Pollinia nuda Trin.	Ch		LC
Cyperaceae.			
Carex appressa R.Br.	H	S	
longifolia R.Br.	H	S	LC
Cyperus difformis L.	H	S	R
tetraphyllus R.Br.	H	S	
Gahnia aspera Spreng... ..	H	S	LC
melanocarpa R.Br.	H	S	LC
Lepidosperma laterale R.Br. ..	H	S	S
Araceae.			
Colocasia macrorrhiza Schott.	Ch	LC	LC
Gymnostachys anceps R.Br. ..	H	LC	S
Commelinaceae.			
Aneilema acuminatum R.Br. ..	Ch	S	F
biflorum R.Br.	Ch	R	R
Pollia crispata Benth. ..	H	LC	LC
Juncaceae.			
Juncus pauciflorus R.Br. ..	H	S	F
Liliaceae.			
Eustrephus latifolius R.Br. ..	M		S
Geitonoplesium cymosum A.Cunn.	M		S
Lomandra Hystrix Fraser & Vickery	H	S	
longifolia Labill.	H		F
montana Fraser & Vickery ..	H	C	
Rhipogonum album R.Br. ..	M	LC	
Smilax australis R.Br... ..	M	F	
Dioscoreaceae.			
Dioscorea transversa R.Br. ..	M	S	F
Orchidaceae.			
Bulbophyllum exiguum F.v.M.	E	C	
Shepherdi F.v.M.	E	C	
Calanthe veratrifolia R.Br. ..	H	LC	
Corysanthes pruinosa A.Cunn.	G		R
Cymbidium suave R.Br. ..	E	F	
Dendrobium aemulum R.Br. ..	E	R	
Beckleri F.v.M.	E	S	
gracilicaule F.v.M.	E	VC	
pugioniforme A.Cunn. ..	E	LC	
speciosum Smith	E	LC	
tenuissimum Rupp	E	R	
teretifolium R.Br.	E	C	
Pterostylis concinna R.Br. ..	G		F
grandiflora R.Br.	G		F
longifolia R.Br.	G		F
nutans R.Br.	G		F
Sarcochilus falcatus R.Br. ..	E	F	
Hillii F.v.M.	E	LC	
olivaceus Lindl.	E	LC	
spathulatus Rogers	E	R	
Spiranthes australis Lindl. ..	G		R
Dicotyledons.			
Casuarineae.			
Casuarina Cunninghamiana Miq.	MM		LC
Piperaceae.			
Peperomia reflexa A.Dietr. ..	E	F	
Piper Novae-Hollandiae Miq.	MM	F	
Ulmaceae.			
Trema cannabina Lour. ..	M	S	F
Moraceae.			
Cudrania javanensis Trécul. ..	M	R	S
Ficus Henneana Miq. ..	MM	F	
stephanocarpa Warb. ..	MM	LC	
Malaisia tortuosa Blanco ..	M	F	
Urticaceae.			
Elatostemma reticulatum Wedd.	Ch	LC	LC
Laportea gigas Wedd.	MM	LC	
Urtica incisa Poir.	Ch		S
Proteaceae.			
Lomatia arborescens Fraser & Vickery	MM	LC	
Orites excelsa R.Br.	MM	C	
Stenocarpus salignus R.Br. ..	MM	LC	

TABLE 1.—*Continued.*

Species.	Life-form.	Main Rain-forest.	Rain-forest Margin.
Loranthaceae.			
Loranthus alyxifolius F.v.M. ..	E	S	
dictyophlebus F.v.M. ..	E	F	
Caryophyllaceae.			
Stellaria flaccida Hook. ..	Ch		LC
Ranunculaceae.			
Clematis aristata R.Br. ..	M		S
glycinoides DC.	M		S
Menispermaceae.			
Sarcopetalum Harveyanum F.v.M.	M	F	F
Stephania hernandifolia Walp.	M	F	F
Anonaceae.			
Eupomatia laurina R.Br. ..	M	C	
Monimiaceae.			
Daphnandra micrantha Benth.	MM	LC	
Doryphora sassafras Endl. ..	MM	VC	
Hedycarya angustifolia A.Cunn.	M		R
Palmeria scandens F.v.M. ..	MM	VC	
Wilkiea macrophylla A. DC. ..	M	LC	
Winteraceae.			
Drimys insipida Druce ..	M	VC	
Lauraceae.			
Cryptocarya erythroxylon Maiden & Betche	MM	F	
glaucescens R.Br.	MM	C	
microneura Meissn.	MM	C	
obovata R.Br.	MM	LC	
patentinervis F.v.M. ..	MM	C	
Endiandra discolor Benth. ..	MM	F	
Muelleri Meissn.	MM	S	
Litsea dealbata Nees	MM	LC	
reticulata Benth.	MM	LC	
Saxifragaceae.			
Abrophyllum ornans Hook. f.	M	R	R
Polyosma Cunninghamii J.J. Benn.	MM	VC	
Quintinia Sieberi A. DC. ..	MM	S	
Pittosporaceae.			
Billardiera scandens A.Cunn. ..	M		F
Citriobatus multiflorus A.Cunn.	N	VC	
Hymenosporum flavum F.v.M.	MM	S	
Pittosporum revolutum Ait. ..	MM	S	
undulatum Andr.	M	S	S
Cunoniaceae.			
Ackama Muelleri Benth. ..	MM	C	LC
Aphanopetalum resinosum Endl.	M	S	S
Callicoma serratifolia Andr. ..	MM	LC	LC
Schizomeria ovata D.Don. ..	MM	VC	
Weinmannia rubifolia Benth...	M	S	LC
Rosaceae.			
Acaena sanguisorba Vahl. ..	Ch		LC
Rubus moluccanus L.	MM	LC	
Moorei F.v.M.	MM	S	
rosaefolius Sm.	N	LC	LC
Leguminosae.			
Acacia elata A.Cunn.	MM		R
melanoxylon R.Br. ..	MM	S	F
mollissima Willd.	M		LC
Desmodium varians Endl. ..	Ch		S
Pithecolobium pruinosum Benth.	MM	R	
Rutaceae.			
Acronychia laevis R. & G.Forst.	MM	F	F
Evodia micrococca F.v.M. var. *pubescens* Fraser & Vickery	M	LC	S
Pleiococca Wilcoxiana F.v.M.	MM	R	
Zieria Smithii Andr.	N		F
Meliaceae.			
Cedrela australis F.v.M. ..	MM	F	
Dysoxylum Fraseranum Benth.	MM	LC	
Synoum glandulosum A.Juss. ..	MM	C	
Euphorbiaceae.			
Baloghia lucida Endl.	MM	C & LVC	
Breynia oblongifolia J.Muell. ..	M	S	F
Claoxylon australe Baill. ..	M	F	
Croton Verreauxii Baill. ..	M	LC	F
Glochidion Ferdinandi J.Muell.	MM	F	F
Homalanthus populifolius Grah.	M		F
Anacardiaceae.			
Rhodosphaera rhodanthema Engl.	MM	S	
Celastraceae.			
Celastrus australis Harv. & F.v.M.	MM	S	
Cunninghamii F.v.M. ..	N		S
Elaeodendron australe Vent. ..	MM	S	
Icacinaceae.			
Chariessa Moorei Engl. ..	MM	S	
Pennantia Cunninghamii Miers	MM	LC	
Sapindaceae.			
Alectryon subcinereus Radlk...	MM	LC	
Arytera foveolata Radlk. ..	M	LC	
Diploglottis Cunninghamii Hook.f.	MM	LC	
Dodonaea megazyga F.v.M. ..	M		LC
Guoia semiglauca Radlk. ..	MM	LC	
Rhamnaceae.			
Alphitonia excelsa Reiss. ..	MM	S	
Emmenospermum alphitonioides F.v.M.	MM	R	
Vitaceae.			
Cayratia clematidea Domin ..	M	S	F
sp.	MM	R	
Cissus antarctica Vent. ..	MM	VC	
hypoglauca A.Gray	MM	VC	
Tetrastigma nitens Planch. ..	MM	R	
Elaeocarpaceae.			
Elaeocarpus obovatus G.Don ..	MM	F	
reticulatus Sm.	MM	F	
Sloanea australis F.v.M. ..	MM	C	

TABLE 1.—*Continued.*

Species.	Life-form.	Main Rain-forest.	Rain-forest Margin.
Malvaceae.			
Hibiscus heterophyllus Vent. ..	M		F
Howittea trilocularis F.v.M. ..	M		S
Sterculiaceae.			
Brachychiton acerifolius F.v.M.	MM	F	
Commerconia echinata R. & G.Forst.	M		LC
Flacourtiaceae.			
Scolopia Brownii F.v.M. ..	M	F	S
Passifloraceae.			
Passiflora alba Link & Otto ..	M		S
Thymelaeaceae.			
Pimelea ligustrina Labill. ..	N		S
Myrtaceae.			
Backhousia myrtifolia Hook. & Harv.	MM	LC	LC
Callistemon salignus DC. ..	MM	R	LC
Eugenia australis Wendl. ..	MM	F	S
Smithii Poir.	MM	LC	S
Eucalyptus saligna Sm. ..	MM	LC	F
Wilkinsoniana R.T.B. ..	MM		S
Myrtus Beckleri F.v.M. ..	N	S	F
Rhodamnia trinervia Blume ..	MM	F	F
Rhodomyrtus psidioides Benth.	M	LC	F
Syncarpia laurifolia Ten. ..	MM	F	
var. *glabra* Benth. ..	MM	R	
Tristania conferta R.Br. ..	MM	S	LC
laurina R.Br.	MM	F	F
Araliaceae.			
Aralia cephalobotrys Harms. ..	M	F	
Astrotricha floccosa DC. ..	M		S
Tieghemopanax elegans R.Viguier	MM	F	
Murrayi R.Viguier ..	MM	F	
sambucifolius R.Viguier ..	M	F	F
Umbelliferae.			
Hydrocotyle hirta R.Br. ..	Ch	S	LC
tripartita R.Br.	Ch-H		LC
Epacridaceae.			
Leucopogon juniperinus R.Br.	N		R
Trochocarpa laurina R.Br. ..	M	LC	C
Myrsinaceae.			
Embelia australasica Mez. ..	M	F	
Rapanea Howittiana Mez. ..	M	R	S
variabilis Mez.	M		S
Sapotaceae.			
Sideroxylon australe Benth. ..	MM	LC	
Ebenaceae.			
Diospyros Cargillia F.v.M. ..	M	LC	F
pentamera F.v.M.	MM	LC	

Species.	Life-form.	Main Rain-forest.	Rain-forest Margin.
Styraceae.			
Symplocos Thwaitsii F.v.M. ..	MM	R	
Apocynaceae.			
Chilocarpus australis R. & G.Forst.	MM	S	
Lyonsia straminea R.Br. ..	MM	C	
Parsonsia velutina R.Br. ..	MM	R	
Asclepiadaceae.			
Tylophora barbata R.Br. ..	M	R	
paniculata R.Br.	M	R	
Convolvulaceae.			
Convolvulus marginatus Poir.	M		R
Boraginaceae.			
Cynoglossum latifolium Poir. ..	Th	R	C
Ehretia acuminata R.Br. ..	MM	F	
Verbenaceae.			
Clerodendron tomentosum R.Br.	M	S	S
Gmelina Leichhardtii F.v.M. ..	MM	R	
Labiatae.			
Plectranthus parviflorus Henck.	Ch	S	F
Solanaceae.			
Duboisia myoporoides R.Br. ..	M	S	F
Solanum laciniatum Ait. ..	M		F
pungetium R.Br.	N		S
stelligerum Sm.	N		F
verbascifolium L.	M		S
Scrophulariaceae.			
Gratiola pedunculata R.Br. ..	H		S
peruviana L.	H		S
Bignoniaceae.			
Tecoma australis R.Br. ..	MM	S	S
Rubiaceae.			
Coelospermum paniculatum F.v.M.	MM	R	
Galium australe DC.	Ch	R	S
umbrosum Sol.	Ch	R	S
Morinda jasminoides A.Cunn.	MM	LC	
Psychotria loniceroides Sieb. ..	M	LC	
Caprifoliaceae.			
Sambucus australasica Fritsch	M	R	
Cucurbitaceae.			
Sicyos angulata L.	M		S
Melothria Cunninghamii Benth.	M		S
Campanulaceae.			
Lobelia trigonocaulis F.v.M. ..	Th	LC	
pedunculata R.Br.	Ch		S
Compositae.			
Helichrysum Beckleri F.v.M. ..	M	R	
Vittadinia australis A.Rich. var. *tenuissima* Benth. ..	N	R	

TABLES 2, 3, 4, 5.

Numbers of species per quadrat are given in three classes: above 30 feet, between 3 and 30 feet, below 3 feet.

The quadrat areas were located as follows: 1.—Lateral gully, 26 quadrats; 2.—Lateral gully, 8 quadrats; 3.—Lower slope of hillside, main valley, 5 quadrats; 4.—Dry slope of hillside, lateral gully, 5 quadrats; 5.—Lower slope of hillside, main valley, 12 quadrats; 6.—Valley floor, 9 quadrats, 7.—Valley floor, 7 quadrats; 8.—Valley floor, 12 quadrats; 9.—Valley floor, 14 quadrats; 10.—Valley floor, 16 quadrats; 11.—Lower slope of hillside, main valley, 22 quadrats; 12.—Upper slope of hillside, main valley in advancing margin zone, 16 quadrats.

TABLE 2.

Numbers of Trees and Shrubs in quadrat areas.

Quadrat Area Numbers.	1			2			3			4			5			6			7			8			9			10			11			12			Total.		
Heights.	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′	>30′	3-30′	<3′
Acacia melanoxylon																1																				1		
Achama Muelleri	8	1	1	3	1	11	1						3		2				1	2	2	3	1		9			6	3			2	7	3	8	13	37	19	36
Acronychia laevis																1	1				4																	4
Alectryon subcinereus							1												2				2			2			5	8				1		1	14	8
Arytera foveolata								3											1										4						5	1		10	4
Backhousia myrtifolia				1																		10	8									1					11	9	
Baloghia lucida					1		6	4								3	1						1		3	2			3	6	5	3		1	1	1	18	15	7
Brachychiton acerifolius		1						1								1													2					1			6	
Callicoma serratifolia	7			1		5							1	1		2												1			2			1		13	1	5
Callistemon salignus																1																				3		
Casuarina Cunninghamiana																10																				10		
Claoxylon australe																1													1							1	1	
Clerodendron tomentosum																														1								1
Croton Verreauxii		1														10	2									3			2							10	8	
Cryptocarya erythroxylon																												1				1	1		8	11	1	9	12
Cryptocarya glaucescens	4	2	4	4	5		3		1	3			1	4	4		1		3			2	5	5	4	14	4	5	9	8	3	8	2				29	51	28
Cryptocarya microneura		1													1	1			1	1			7	4	1			2	1	1	1	4			2	21	4	17	28
Cryptocarya obovata		1	1					1						1									1			1		1	2	1		2	2	1		7	2	8	12
Cryptocarya patentinervis		2	2																18	2			2	3		9			2			2		1	2		1	37	7
Daphnandra micrantha								2	2											8		1	13	4		2		3	4	11		3	1		4	5	4	28	31
Diospyros Cargillea							3		3										1				1	4	2					2		4	1		1		5	7	10
Diospyros pentamera	1							4	1					1									1	1		2	1	3	15	1	2	8		1	4	2	7	32	4
Diploglottis Cunninghamii	1	1										1		1		2							1							15		1	1		2	2	3	8	21
Doryphora sassafras	8	7		3	1		2	1		1			3	7	1		1						1		3	13	9	12	9		2	7		3	8	4	37	55	14
Drimys insipida		22	14		3	12		2	1	1	2			11	14				15	5			14	3	1	10	1		5	2		40	18		26	29	1	149	101
Dysoxylum Fraseranum		1						7									1											1	14	8	1	1	1	1	1		3	18	16
Ehretia acuminata																1									2												3		
Elaeocarpus reticulatus		1														1										1		1	3	2		2					2	7	2
Elaeocarpus obovatus																													2					1			1		
Elaeodendron australe																			1																		1		
Endiandra discolor																												1			1						1		
Eucalyptus saligna	1																					1			6	1		2			3						13	1	
Emmenospermum alphitonioides																																			1			1	
Eugenia australis		2																				1	1			1											1	5	
Eugenia Smithii	1	3			4			1					1	1	3				1	3		2	9	3	2	8	14	1	13	3	12	1		1		8	20	41	34
Evodia micrococca var. pubescens																3		3								1		2	2							5	3	3
Eupomatia laurina		1												1											2	3		2	2	1	2	2	1		4	1	6	13	3
Ficus stephanocarpa										1						3							1														3	1	
Gucia semiglauca		1	2				1						1			3	3		2	6	3	1	2	2	1	5		2	1		3	6	13		3	4		5	18	12	31	42
Hymenosporum flavum													2			1										1											4	3	
Laportea gigas																9	2								3												12	2	
Litsea dealbata					1	6		6		1				1								1	1					1	3	14		7			2	2	2	16	28
Lomatia arborescens																3																					3		
Myrtus Beckleri																	1							1									1	2		1	2	2
Orites excelsa	4	1	13	1	2	23		2	1				3	4	30							1			1	4		4	8	17	4	6	1	3	6	8	21	33	93
Pennantia Cunninghamii																																1					1	1	
Phyllanthus Ferdinandi																						1															1		
Polyosma Cunninghamii	2	3	7	1	1		2		25				1	2														7	12	43	2	3	10	1	1	6	16	22	91
Psychotria loniceroides		1												2	1		2		5				4		1		2		1							1	13	2
Quintinia Sieberi																																						2	1
Rapanea Howittiana																																1						1	
Rhodamnia trinervia																			1	1		1							1		3					4	2	1
Schizomeria ovata	8		1	1	2								2	4					7	4		8			10	6		6	1		3	2		2	1	47	20	1
Scolopia Brownii																			1		1																1		1
Sideroxylon australe		2					1																7		1			4	9	5				1	2	6	19	7
Sloanea australis	3	6	5		4	11			5	2			3	1	5					1		3	2		3	10	1	1	6	14	5	2		2	6	9	22	37	51
Stenocarpus salignus	1	1	1			5														2	3		5				1			3		2				1	8	15
Synsepala laurifolia	2		1													1	1		2			6			3					2			3			19	1	1
Synoum glandulosum		2		2	2	7		1					1	1	1					1			4	1		2	1							2			3	14	11
Tristania laurina			1										2	1		2			1	2		3						4									10	3	3
Trochocarpa laurina					2											1			1	2			5		1	4		1									3	14	
Charlesia Moorei		1			1																		1			1			2									6	
Weinmannia rubifolia																2																						2	
Wilkiea macrophylla		2																	2	1		1	4	1		2	1		2			1				1	13	3

TABLE 3.

Numbers of Lianes in quadrat areas.

Quadrat Area Numbers.	1			2		3			4			5			6			7			8			9			10			11			12			Total		
Heights.	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'	>30'	3-30'	<3'
Aphanopetalum resinosum													2								1	3		2										3	5	
Celastrus australis																								1											1	
Chilocarpus australis	2	1	3																						3					1	2	2	6	3	5
Cissus antarctica	8		1	4		3	2			3			2		1	6	2	2				1	3		4	1		12	2	11	2		1	1	1		45	9	19
Cissus hypoglauca	7	1					1			1			3									3			3			6	1		4			2	1		30	3	
Clematis aristata		1	1																				1												2	1
Dioscorea transversa												1			1								2									2	3		6	3
Embelia australasica																		1							1			1						1	2	
Eustrephus latifolius																1																				1
Ficus Henneana																					1													1		
Lyonsia straminea	2	4	2	2		2			1	1		4	2	2							1	2			1	2	1	2						7	18	7
Malaisia tortuosa		6					1	2	1							1														1				2	9	1
Morinda jasminoides			3					3				1					1				2			2		14	1	3	4	1	1	3	5	10	24
Palmeria scandens	5	7	41	4	23					2		2	15	2			1	1			2			2	3	8		14	51		1	2	3	16	14	32	159
Piper Novae-Hollandieae	1	1		2			1			3																	2	1						4	7	
Rhipogonum album																						13	5	1	2	1		4	7		11	7	3	1	30	23
Rubus Moorei																						1			1	1		1							3	1
Smilax australis		2		1			1		1	1					1			1				6					1	1						3	12	3
Tecoma australis			1														1								1								1	1	1	2
Tylophora barbata		1							1						1																				3	

TABLE 4.

Frequencies of Ferns and other Ground Flora Species in Quadrat Areas.

VN, very numerous; N, numerous; F, frequent; S, scanty; R, rare.

(The ground flora species were not recorded in areas 11 and 12.)

Quadrat area	1	2	3	4	5	6	7	8	9	10
Pteridophytes.										
Adiantum affine			S					S		
formosum						S			S	
hispidulum	N									
Alsophila Leichhardtiana ..	N	N		N	N	S			S	
Arthropteris Beckleri					S					
tenella	S		N	S	S	S		S	S	N
Asplenium adiantoides		S		S	S	S	S		S	S
nidus	S	S		S	F	F	S			S
Athyrium umbrosum						N				S
Blechnum capense		S								
cartilagineum	N	S	S	S	S	N		S	S	
Patersoni	F	S		S	F					
Cyclophorus confluens			S			S			S	S
Davallia pyxidata				S	S				S	
Dennstaedtia davallioides ..						S	S			
Dicksonia antarctica		S								
Doodia aspera							S	S		
Dryopteris acuminata		S			S					
decomposita	N	F	N	F	N	F	F	N	F	VN
parasitica						S				
Pellaea falcata		S	S		F			S		
Platycerium bifurcatum	F	S	S	S	S	S	S	S	S	S
Pleopeltis Brownii					S	S		S	S	
pustulata	F	F	S	S	N	F		S	S	N
Pteris umbrosa			S		S					
Trichomanes caudatum		R		F						
Angiosperms.										
Aneilema acuminatum						S		S	S	
Calanthe veratrifolia								S		
Citriobatus multiflorus	S	S	N	S	S	N	N	F	F	S
Colocasia macrorrhiza	F								S	S
Gahnia aspera			S				S			S
Gymnostachys anceps									S	
Lomandra montana		S	F	F	N	F	F	F	F	F
Oplismenus imbecillus								S		
Pollia crispata						S		S		

TABLE 5.

Density of the Flora in the Quadrat Areas.

Quadrat area.	Number of Plants (excluding Ferns and less important Herbs) per 100 Square Feet.								Percentages.					
	Trees.	Saplings.	Shrubs.	*Alsophila*.	Total (of trees, saplings, shrubs and *Alsophila*).	*Citriobatus*.	*Lomandra*.	Seedlings (of shrubs and trees).	Trees.	Saplings.	Shrubs.	*Alsophila*.	*Citriobatus*.	Seedlings.
1	3·11	2·62	1·62	7·9	15·25	0·73	2·9	3·2	20·4	17·1	10·7	51·8	3·9	30·3
2	3·38	5·36	0·59	8·5	17·83	0·4	1·58	15·9	18·9	30·1	3·3	47·7	11·1	63·0
3	6·03	5·08	0·63	—	11·74	6·66	2·5	17·6	51·4	43·2	5·3	—	31·9	59·9
4	1·9	0·63	0·31	15·2	18·04	0·63	0·32	1·0	10·5	3·5	1·7	84·2	3·3	26·0
5	3·17	4·23	1·58	8·3	17·28	0·53	5·4	8·2	18·3	24·5	9·1	48·0	2·2	47·7
6	9·15	4·86	—	0·53	14·54	5·29	2·3	0·5	62·9	33·4	—	3·7	23·9	3·4
7	3·4	11·3	3·85	—	18·55	0·97	3·4	8·8	18·3	60·9	20·7	—	4·2	32·3
8	5·55	11·5	2·38	—	19·43	3·96	3·8	3·9	28·4	59·2	12·3	—	14·6	16·7
9	6·80	11·9	2·15	—	20·85	3·17	1·5	3·8	32·6	57·1	10·3	—	12·4	15·4
10	6·84	15·3	1·09	0·16	23·39	11·1	2·6	18·1	29·1	65·1	4·6	0·7	29·1	43·8
11	4·25	5·34	5·98	0·29	15·86	3·3	2·4	3·8	26·8	33·7	37·7	1·8	15·3	19·5
12	2·57	7·34	3·17	1·09	14·17	9·8	4·9	14·9	18·1	51·8	22·2	7·7	34·0	53·2

The percentages of the trees, saplings, shrubs and *Alsophila* are expressed as the percentage of the total number of plants of these four groups. The percentage of *Citriobatus* is expressed as the percentage of the total number of all the groups except the seedlings. The percentage of seedlings is expressed as the percentage of the total number of the tree, sapling, shrub and seedling groups.

TABLE 6.

List of Rain-Forest Species observed in the Upper Chichester and Manning River Valleys.

Species.	Upper Chichester.	Upper Manning.
Pteridophytes.		
Cyatheaceae.		
Alsophila Leichhardtiana F.v.M.	X	
Dicksonia antarctica Labill. ..	X	
Polypodiaceae.		
Adiantum affine Willd.	X	
formosum R.Br.	X	
hispidulum Sw.	X	
Arthropteris tenella J.Sm. ..	X	
Asplenium adiantoides C.Chr. ..	X	
nidus L.	X	
Athyrium umbrosum Presl. ..	X	
Blechnum capense Schlecht. ..	X	
cartilagineum Sw.	X	
discolor Keys	X	
Cyclophorus serpens C.Chr. ..	X	
Diplazium japonicum Beddome	X	
Doodia aspera R.Br.	X	
Dryopteris decomposita O. Kuntze	X	
parasitica O. Kuntze ..		X
Hypolepis tenuifolia Bernh. ..	X	
Platycerium bifurcatum C.Chr. ..	X	
Pteris umbrosa R.Br.	X	
Gleicheniaceae.		
**Gleichenia flabellata* R.Br. ..	X	
Angiosperms.		
Monocotyledons.		
Cyperaceae.		
Gahnia aspera Spreng.	X	
melanocarpa R.Br.	X	
Araceae.		
**Typhonium Brownii* Schott. ..		X
Liliaceae.		
Lomandra hystrix Fraser & Vickery	X	
montana Fraser & Vickery ..	X	
Smilax australis R.Br.		X

* Species not found in the Williams River valley.

TABLE 6.—*Continued.*

Species.	Upper Chichester.	Upper Manning.
Dioscoreaceae.		
Dioscorea transversa R.Br. ..		X
Dicotyledons.		
Piperaceae.		
Piper Novae-Hollandiae Miq. ..	X	
Ulmaceae.		
**Aphananthe philippinensis* Planch.		X
Trema cannabina Lour.		X
Moraceae.		
Cudrania javanensis Tréc. ..		X
**Ficus macrophylla* Desf. ..		X
stephanocarpa Warb. ..	X	X
Malaisia tortuosa Blanco ..	X	
**Pseudomorus Brunoniana* Bur. ..		X
Urticaceae.		
Laportea gigas Wedd.		X
* *photiniphylla* Wedd.		X
Proteaceae.		
Orites excelsa R.Br.	X	X
Stenocarpus salignus R.Br. ..	X	
Santalaceae.		
**Santalum obtusifolium* R.Br. ..		X
Amarantaceae.		
**Deeringia celosioides* R.Br. ..		X
Ranunculaceae.		
Clematis glycinoides DC. ..	X	X
Menispermaceae.		
Legnephora Moorei Miers ..		X
Sarcopetalum Harveyanum F.v.M.		X
Stephania hernandifolia Walp. ..		X
Anonaceae.		
Eupomatia laurina R.Br. ..	X	
Monimiaceae.		
Daphnandra micrantha Benth. ..	X	X
Doryphora sassafras Endl. ..	X	
Wilkiea macrophylla A.DC. ..	X	X
Palmeria scandens F.v.M. ..	X	
Winteraceae.		
Drimys insipida Druce	X	
Lauraceae.		
Cryptocarya glaucescens R.Br. ..	X	X
microneura Meissn.	X	X
obovata R.Br.	X	
Cryptocarya patentinervis F.v.M.	X	
Endiandra Muelleri Meissn. ..	X	
Litsea dealbata Nees		X
* *zeylandica* Nees		X
Capparidaceae.		
**Capparis nobilis* F.v.M.		X
Pittosporaceae.		
Citriobatus multiflorus A.Cunn.	X	X
Hymenosporum flavum F.v.M. ..	X	
Pittosporum revolutum Ait. ..		X
undulatum Andr.	X	

Species.	Upper Chichester.	Upper Manning.
Cunoniaceae.		
Ackama Muelleri Benth. ..	X	X
Aphanopetalum resinosum Endl.		X
Callicoma serratifolia Andr. ..	X	
Schizomeria ovata D.Don. ..	X	
Rosaceae.		
Rubus moluccanus L.		X
Moorei F.v.M.		X
rosaefolius Sm...		X
Leguminosae.		
Acacia elata A.Cunn.	X	
melanoxylon R.Br.	X	
mollissima Willd.		X
**Cassia sophora* L. var. *schinifolia* Benth.		X
Lonchocarpus Blackii Benth. ..	X	X
Pithecolobium pruinosum Benth.		-X
**Tephrosia purpurea* Pers. ..		X
Rutaceae.		
Acronychia laevis R. & G.Forst.	X	X
Evodia micrococca F.v.M. ..		X
**Geijera salicifolia* Schott. ..		X
Meliaceae.		
Cedrela australis F.v.M. ..	X	X
Dysoxylum Fraseranum Benth.	X	X
**Melia Azedarach* L.		X
Synoum glandulosum A.Juss. ..	X	X
Euphorbiaceae.		
**Alchornea ilicifolia* J.Muell. ..		X
Baloghia lucida Endl.	X	X
Breynia oblongifolia J.Muell. ..	X	X
Claoxylon australe Baill. ..		X
Croton Verreauxii Baill. ..	X	X
Glochidion Ferdinandi J.Muell.	X	
**Mallotus philippinensis* J.Muell.		X
Anacardiaceae.		
Rhodosphaera rhodanthema Engl.		X
Celastraceae.		
Celastrus Cunninghamii F.v.M.		X
Elaeodendron australe Vent. ..		X
Sapindaceae.		
Alectryon subcinereus Radlk. ..	X	X
* *subdentatus* Radlk.		X
Diploglottis Cunninghamii Hook.	X	X
Dodonaea triquetra Wendl. ..		X
**Elattostachys nervosa* Radlk. ..		X
Guoia semiglauca Radlk. ..	X	X
Rhamnaceae.		
Alphitonia excelsa Reiss. ..		X
Vitaceae.		
Cayratia clematidea Domin. ..		X
Cissus antarctica Vent.	X	X
hypoglauca A.Gray.	X	X
Tetrastigma nitens Planch. ..		X

TABLE 6.—*Continued.*

Species.	Upper Chichester.	Upper Manning.	Species.	Upper Chichester.	Upper Manning.
Elaeocarpaceae.			Myrsinaceae.		
Elaeocarpus obovatus G.Don. ..		X	*Embelia australasica* Mez. ..		X
reticulatus Sm.	X		*Rapanea variabilis* Mez. ..		X
Sloanea australis F.v.M... ..	X		Ebenaceae.		
* *Woollsii* F.v.M.	X		*Diospyros Cargillia* F.v.M. ..		X
Malvaceae.			Sapotaceae.		
Hibiscus heterophyllus Vent. ..	X		*Sideroxylon australe* Benth. ..	X	X
Sterculiaceae.			Oleaceae.		
Brachychiton acerifolius F.v.M.	X	X	**Jasminum simplicifolium* G.Forst.		X
**Tarrietia actinophylla* Bailey ..		X	*Notelaea venosa* F.v.M.		X
Violaceae.			Apocynaceae.		
Hymenanthera dentata R.Br. ..		X	**Alyxia ruscifolius* R.Br. ..		X
Myrtaceae.			*Lyonsia Brownii* Britten ..		X
Backhousia myrtifolia Hook. &			Boraginaceae.		
Harv.	X		*Ehretia acuminata* R.Br. ..	X	X
* *sciadophora* F.v.M.		X	Verbenaceae.		
Callistemon salignus DC. ..		X	*Clerodendron tomentosum* R.Br.	X	X
**Decaspermum paniculatum* Baill.		X	Solanaceae.		
Eucalyptus saligna Sm. ..	X	X	*Duboisia myoporoides* R.Br. ..	X	X
Eugenia australis Wendl. ..	X	X	Bignoniaceae.		
Smithii Poir.	X	X	*Tecoma australis* R.Br.	X	
* var. *minor* Maiden & Betche		X	Acanthaceae.		
Myrtus Beckleri F.v.M.	X	X	*Eranthemum variabile* R.Br. ..		X
Rhodamnia trinervia Blume ..		X	**Justicia procumbens* L.		X
Rhodomyrtus psidioides Benth. ..	X		Myoporaceae.		
Syncarpia laurifolia Ten. ..	X		**Myoporum acuminatum* R.Br. ..		X
Tristania conferta R.Br. ..	X		Rubiaceae.		
laurina R.Br.	X		*Morinda jasminoides* A.Cunn. ..	X	X

TABLE 7.

List of Species occurring in the Sub-antarctic Rain-Forest.

VC, very common; C, common; LC, locally common; F, frequent; S, scanty; R, rare.

Species.	Frequency.	Trees.	Shrubs.	Herbs.	Lianes.	Epiphytes.	Species.	Frequency.	Trees.	Shrubs.	Herbs.	Lianes.	Epiphytes.
Pteridophytes.							*Blechnum Patersoni*						
Hymenophyllaceae.							Mett.	LC			X		
Hymenophyllum flabellatum Labill. ..	S			X			*Dennstaedtia davallioides* Moore ..	F			X		
Cyatheaceae.							*Dryopteris acuminata*						
Dicksonia antarctica							Watts	LC			X		
Labill.	VC		X				*Histiopteris incisa*						
Polypodiaceae.							J.Sm.	F			X		
Arthropteris tenella							*Hypolepis tenuifolia*						
J.Sm.	S			X			Bernh.	F			X		
Asplenium bulbiferum							*Pleopeltis pustulata*						
Forst.	LC			X			Moore	S			X		

TABLE 7.—*Continued.*

Species.	Frequency.	Trees.	Shrubs.	Herbs.	Lianes.	Epiphytes.
Polypodium Billardieri C.Chr.	F			X		
Polystichum aculeatum Schott.	VC			X		
Pteris umbosa R.Br.	F			X		
Angiosperms.						
Monocotyledons.						
Gramineae.						
Poa caespitosa G.Forst.	S			X		
Cyperaceae.						
Uncinia riparia R.Br.	S			X		
Liliaceae.						
Lomandra longifolia Labill.	F			X		
Smilax australis R.Br.	C				X	
Iridaceae.						
Libertia pulchella Spreng.	S			X		
Orchidaceae.						
Dendrobium falcorostrum Fitzg. ..	R					X
Dicotyledons.						
Fagaceae.						
Nothofagus Moorei Oerst.	VC	X				
Urticaceae.						
Australina pusilla Gaud.	F			X		
Elatostemma reticulatum Wedd. ..	LC			X		
Urtica incisa Poir. ..	F			X		
Proteaceae.						
Lomatia arborescens Fraser & Vickery	F		X			
Caryophyllaceae.						
Stellaria flaccida Hook.	F			X		
Ranunculaceae.						
Clematis aristata R.Br.	S				X	
Winteraceae.						
Drimys purpurascens J.Vickery ..	S		X			
Monimiaceae.						
Atherosperma moschatum Labill. ..	F	X				
Doryphora sassafras Endl.	F	X				

Species.	Frequency.	Trees.	Shrubs.	Herbs.	Lianes.	Epiphytes.
Hedycarya angustifolia A.Cunn.	F		X			
Cruciferae.						
Cardamine hirsuta L.						
var. *tenuifolia* F.v.M.	S			X		
Saxifragaceae.						
Quintinia Sieberi A.DC.	R	X				
Pittosporaceae.						
Pittosporum undulatum Andr.	S	X				
Citriobatus multiflorus A.Cunn.	LC		X			
Cunoniaceae.						
Weinmannia rubifolia Benth.	R	X				
Rosaceae.						
Rubus moluccanus L.	S				X	
parvifolius L. ..	S		X			
Acaena sanguisorba Vahl.	F			X		
Vitaceae.						
Cissus antarctica Vent.	S				X	
Elaeocarpaceae.						
Elaeocarpus holopetalus F.v.M.	F	X				
Flacourtiaceae.						
Streptothamnus Beckleri F.v.M.	F				X	
Violaceae.						
Hymenanthera dentata R.Br.	S		X			
Epacridaceae.						
Trochocarpa laurina R.Br.	LC	X	X			
Oleaceae.						
Notelaea venosa F.v.M.	F		X			
Apocynaceae.						
Lyonsia Brownii Britten	S				X	
Scrophulariaceae.						
Veronica notabilis F.v.M.	F			X		
Rubiaceae.						
Galium umbrosum Sol.	S			X		

TABLE 8.

Results of Quadrats Examined in the Sub-antarctic Rain-Forest.

	Group 1. (10 quadrats.)			Group 2. (17 quadrats.)		
	>30 feet.	3–30 feet.	<3 feet.	>30 feet.	3–30 feet.	<3 feet.
Acacia melanoxylon			1			
Asplenium bulbiferum			1			
Doryphora sassafras				5	7	
Drimys purpurascens		1	2		1	
Eucalyptus campanulata		1				
pauciflora	2					
Dysoxylum Fraseranum				1		1
Elaeocarpus holopetalus		1		1		
Hedycarya angustifolia					2	
Lomatia arborescens		11	3		1	
Notelaea venosa			1		1	
Nothofagus Moorei	12	6	1	19	5	
Trochocarpa laurina			4		6	
Total number of plants	14	20	13	26	23	1

TABLE 9.

Frequencies of Trees, Saplings and Shrubs in the Quadrat Areas examined in the Sub-antarctic Rain-Forest.

Quadrat Area.	Number of Plants per 100 Square Feet.					Percentages.		
	Trees.	Saplings.	Shrubs.	Saplings + Shrubs.	Total.	Trees.	Saplings.	Shrubs.
Group 1 (10 quadrats) ..	2·4	3·2	2·0	5·2	7·6	31·8	42·1	26·3
Group 2 (17 quadrats) ..	2·4	2·1	0·1	2·2	4·6	52·2	45·6	2·2

TABLE 10.

List of Species Recorded from Comboyne, Dorrigo, Port Macquarie, Upper Hastings River and Krambach Mountain, which have not been observed in the Williams River Valley.

	Comboyne.	Dorrigo.	Port Macquarie.	Upper Hastings River.	Krambach Mountain.
Pteridophyta.					
Polypodiaceae.					
Arthropteris obliterata J.Sm.	X				
Dryopteris Queenslandica Domin.	X				
Gymnosperms.					
Taxaceae.					
Podocarpus elata R.Br. ..			X		
Pinaceae.					
Araucaria Cunninghamii Ait.		X			
Angiosperms.					
Monocotyledons.					
Palmeae.					
Archontophoenix Cunninghamiana Wendl. et Drude		X	X		
Calamus Muelleri Wendl.		X			
Linospadix monostachyus Wendl.		X			
Araceae.					
Pothos longipes Schott. ..	X	X			
Flagellariaceae.					
Flagellaria indica L. ..			X		
Liliaceae.					
Cordyline stricta Endl. ..	X		X		
Drymophila Moorei Baker	X				
Kreyssigia multiflora Reichb.	X	X	X		
Rhipogonum discolor F.v.M.		X			
Dicotyledons.					
Moraceae.					
Ficus Bellingeri C.Moore ..		X			
macrophylla Desf. ..	X	X			X
rubiginosa Desf. ..	X				
Pseudomorus Brunoniana Bur.		X			X
Urticaceae.					
Elatostemma stipitatum Wedd.	X	X			
Laportea photiniphylla Wedd.		X			
Proteaceae.					
Helicia glabrifolia F.v.M.	X	X			
Youngiana F.v.M. ..		X			
Menispermaceae.					
Legnephora Moorei Miers.	X				
Amarantaceae.					
Deeringia celosioides R.Br.					X
Phytolaccaceae.					
Codonocarpus attenuatus H.Walter					X
Monimiaceae.					
Daphnandra tenuipes Perk.	X				
Piptocalyx Moorei Oliv. ..	X	X			
Lauraceae.					
Cinnamomum Oliveri Bailey	X				
virens R.T.Baker ..	X				
Cryptocarya Meissneri F.v.M.	X	X			
Endiandra Sieberi Nees ..	X				
Capparidaceae.					
Capparis nobilis F.v.M. ..	X		X		
Saxifragaceae.					
Anopterus glandulosus Labill.			X		
Macleayanus F.v.M. ..	X				
Cuttsia viburnea F.v.M. ..	X	X			
Quintinia Verdonii F.v.M.	X				
Cunoniaceae.					
Ceratopetalum apetalum D.Don.	X				
Geissois Benthami F.v.M. ..	X				
Leguminoseae.					
Castanospermum australe A.Cunn.	X	X			
Milletia australis Benth. ..		X			
Rutaceae.					
Acronychia Baueri Schott.	X	X			X
melicopoides F.v.M. ..		X			
Bosistoa euodiformis F.v.M.	X				
Flindersia Oxleyana F.v.M.		X			
Geijera salicifolia Schott.	X				
Xanthoxylum brachyacanthum F.v.M. ..					X
Simarubaceae.					
Guilfoylia monostylis F.v.M.		X			
Meliaceae.					
Dysoxylum rufum Benth.	X				X
Euphorbiaceae.					
Acalypha nemorum F.v.M.				X	
Alchornea ilicifolia J.Muell.				X	X
Cleistanthus Cunninghamii J.Muell.			X	X	
Croton insularis Baill. ..		X			
phebalioides F.v.M. ..					X
Celastraceae.					
Denhamia pittosporoides F.v.M.	X				
Sapindaceae.					
Castanospora Alphandi F.v.M.		X			
Elattostachys nervosa Radlk.				X	
Harpullia pendula Planch.		X			
Sarcopteryx stipitata Radlk.	X	X			
Akaniaceae.					
Akania Hillii Hook.f. ..	X	X			

TABLE 10.—*Continued.*

	Comboyne.	Dorrigo.	Port Macquarie.	Upper Hastings River.	Krambach Mountain.
Elaeocarpaceae.					
Aristotelia australasica F.v.M.		X			
Sloanea austroqueenslandica Domin.	X				
Woollsii F.v.M. ..	X				
Sterculiaceae.					
Ruelingia pannosa R.Br. ..		X			
Sterculia lurida Benth. ..					X
Tarrietia actinophylla Bailey	X	X			
argyrodendron Benth. ..				X	X
Myrtaceae.					
Backhousia sciadophora F.v.M.					X
Eucalyptus microcorys F.v.M.				X	
Eugenia Coolminiana C.Moore	X				
corynantha F.v.M. ..	X				
cyanocarpa F.v.M. ..	X				
Myrtus rhytisperma F.v.M.		X			
Melastomaceae.					
Melastoma malabathricum L.		X			
Oleaceae.					
Olea paniculata R.Br. ..	X				
Apocynaceae.					
Alyxia ruscifolius R.Br...	X				
Tabernaemontana orientalis R.Br.		X			
Asclepiadaceae.					
Hoya australis R.Br. ..		X			
Gesneraceae.					
Fieldia australis A.Cunn...	X				
Acanthaceae.					
Justicia procumbens L. ..				X	
Myoporaceae.					
Myoporum acuminatum R.Br.	X	X			
Rubiaceae.					
Psychotria daphnoides A.Cunn.		X			

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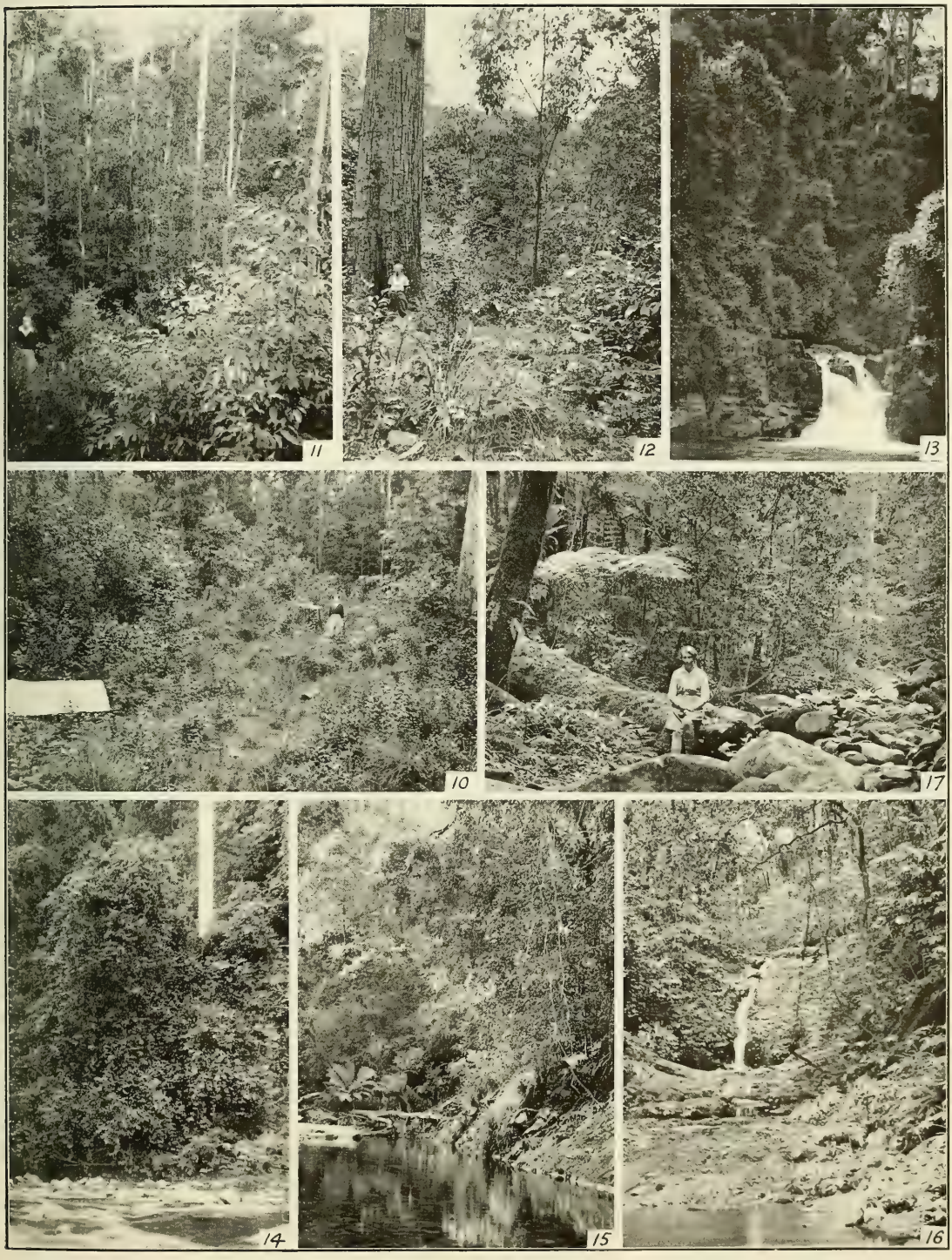

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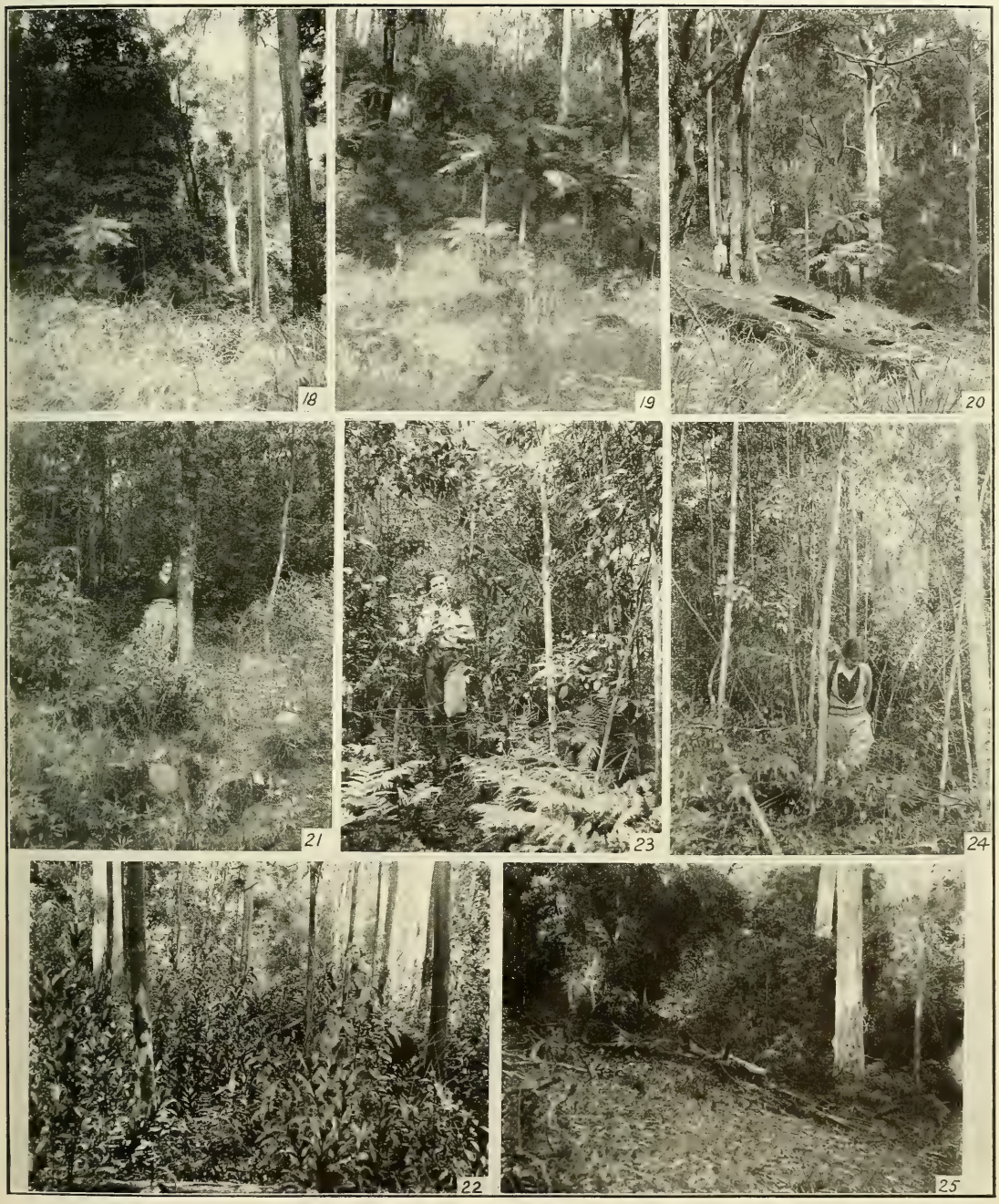

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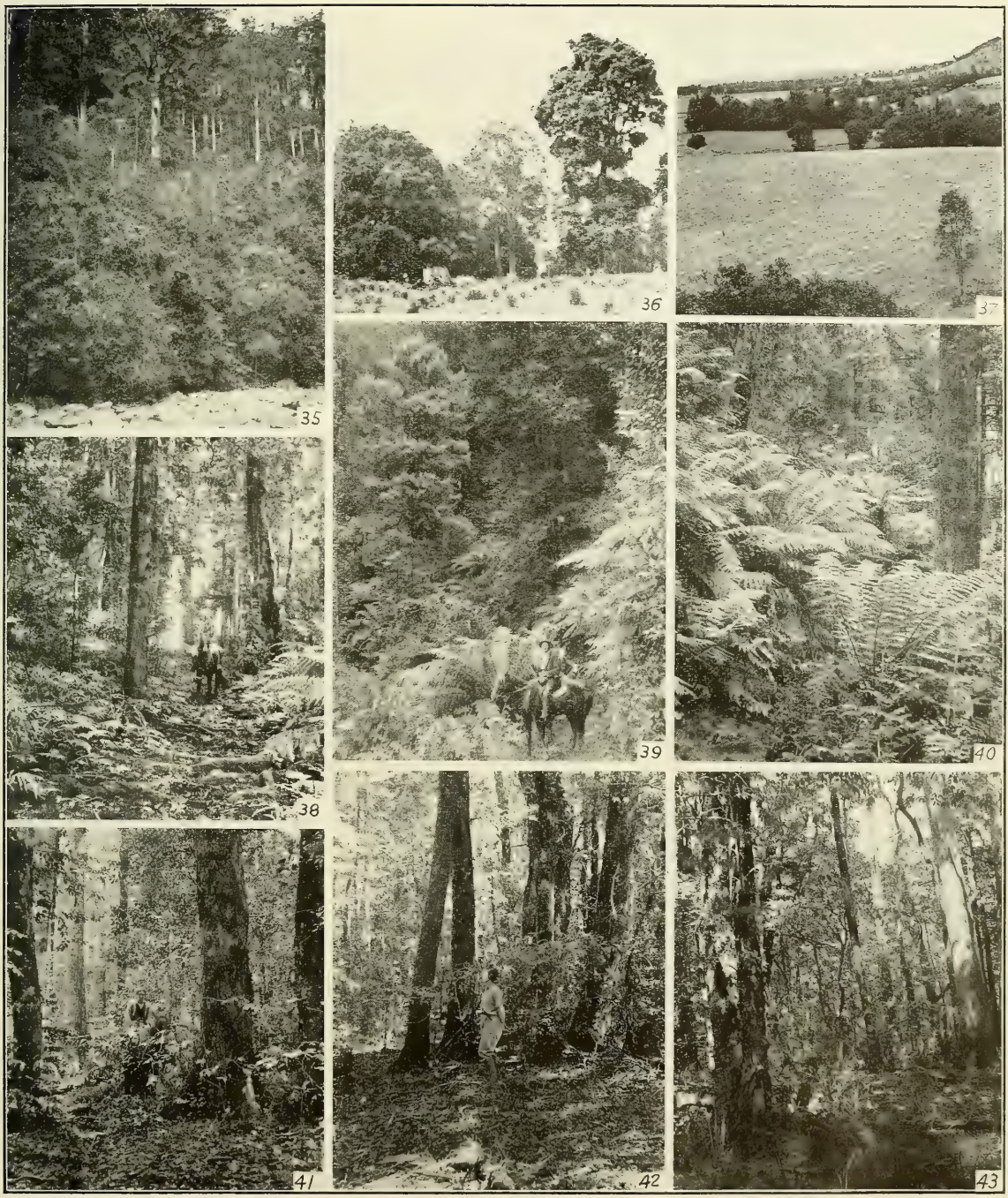

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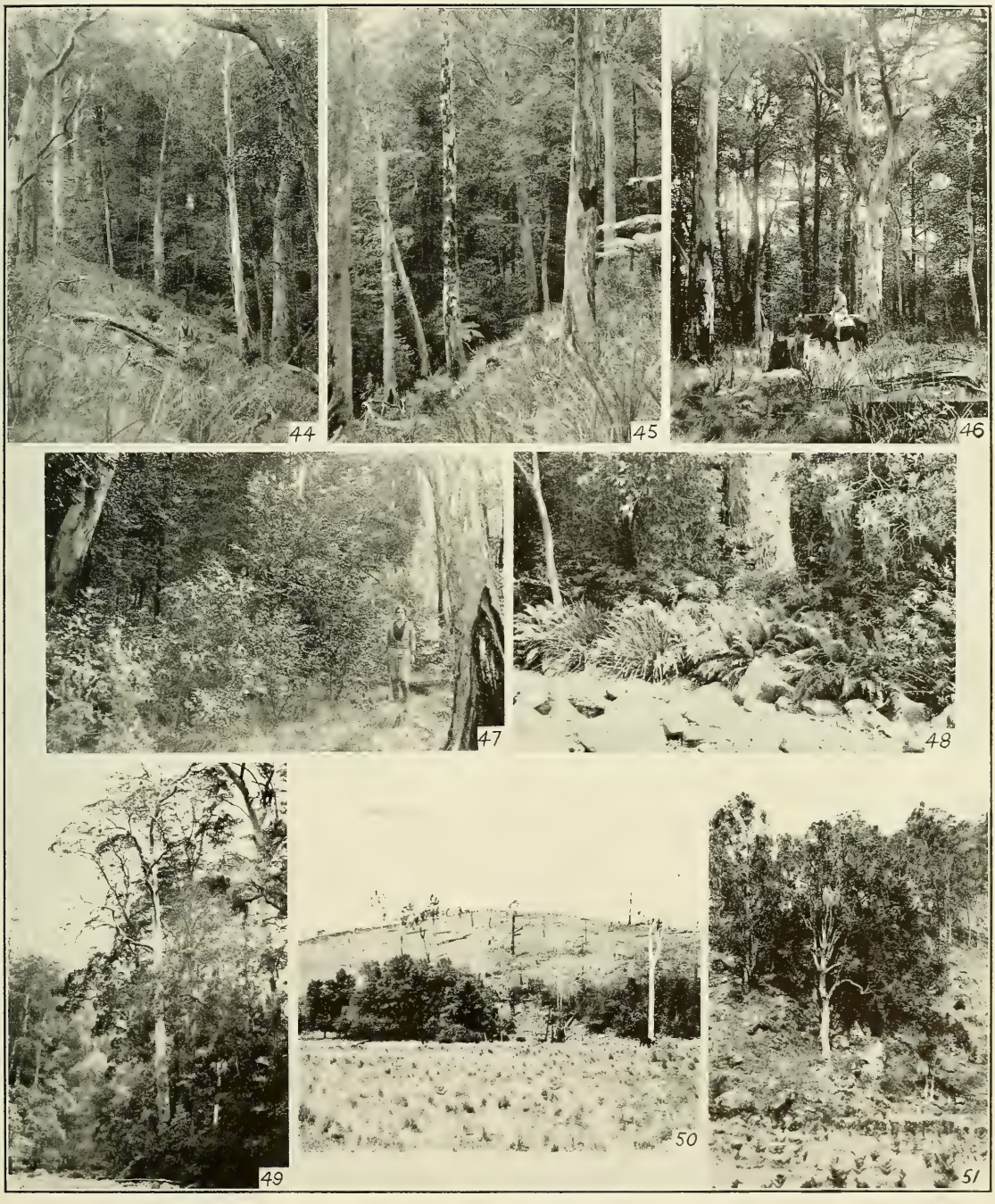

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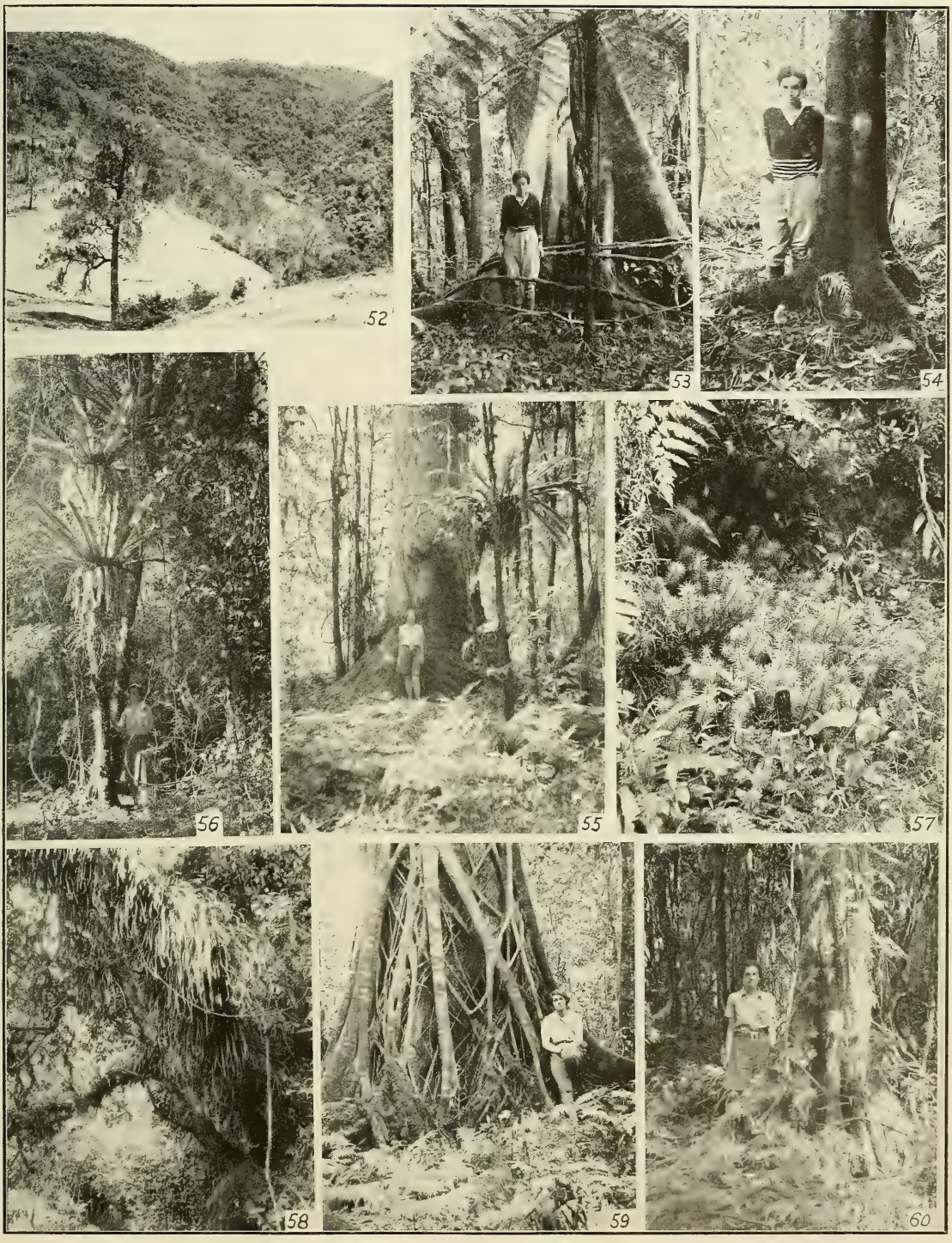

Ecology of Williams River and Barrington Tops Districts.

NEW SPECIES AND RECORDS OF TACHINIDAE (DIPTERA).

By C. H. Curran.
(*Communicated by Frank H. Taylor, F.R.E.S., F.Z.S.*)

(Two Text-figures.)

[Read 27th July, 1938.]

The species described in the following pages are from various collections and are mostly new. A few previously-known species are redescribed.

Besserioides, n. gen.

Intermediate between *Besseria* Desv. and *Hyalomyia* Desv. The front is wide in both sexes, the abdomen intermediate in shape between the two genera, broader and less convex than in *Besseria* and much less flattened than in *Hyalomyia*.

Face very slightly receding, the oral margin very little produced; oral vibrissae weak, situated only a little above the oral margin; front about half as wide as greatest width of one eye; ocellars weak; cheeks one-sixth as wide as eye-height, the oral margin oblique on its anterior third. Antennae situated above the middle of the eyes, reaching almost to the oral margin, the third segment two and one-half times as long as wide, convex apically, the second segment short, arista bare. Parafacials bare; front with a single row of short, convergent bristles on either side. Mesonotum with only bristles laterally and very weak ones posteriorly; scutellum with two pairs of marginal bristles; sternopleurals varying from two to four in a horizontal line. Legs simple. Wings as in *Alophora* and *Besseria*. Abdomen oval, moderately convex, without bristles; in both sexes the third sternite is evidently absent, the first is broad, the second triangular and small; in the female the fourth and fifth sternites are large and convex and the piercing ovipositor rests at an angle of about 45° to the horizontal plane of the abdomen. Genotype, *Besserioides sexualis*, n. sp.

Besserioides sexualis, n. sp.

Wings of ♂ tinged with brown, especially anteriorly; of ♀ somewhat paler; abdomen of ♂ rusty reddish-yellow, of ♀ shining black. Length 4 to 5·5 mm.

♂. Head reddish in ground colour, the occiput and parafrontals black; front, face and cheeks rich yellowish pollinose, the occiput cinereous; frontal vitta much wider than either parafrontal, the frontal bristles not extending above the upper fourth of the front. Occipital cilia extending only to the level of the antennae; pile of the occiput and cheeks whitish or yellowish, the cheeks without bristles. Palpi pale reddish. Antennae pale orange, the third segment darkened above on the apical half; arista brown, thickened on the basal fifth. Thorax black, moderately clothed with brownish cinereous pollen, the pleura with brighter coloured pollen. Hair short and black. Scutellum sometimes mostly reddish. Legs black; pulvilli brown. Wings tinged with brownish, the apical cell long petiolate. Appendage of fifth vein continued to the wing-margin in its full

strength; posterior cross-vein situated nearer the anterior cross-vein than to the bend of the fourth vein, which is a broad curve. Abdomen yellowish-red, shining, clothed with very short, appressed black hair. Genitalia rather small.

♀. Head wholly cinereous white pollinose, the parafrontals less thickly so above. Thorax with whitish cinereous pollen. Wings not so strongly tinged with brown. Abdomen shining black, the scutellum never reddish.

Type ♂, Laidley, Queensland, 8th Nov., 1927; allotype, ♀, Laidley, 5th Jan., 1928; paratypes, 5 ♂, 3 ♀, from Brisbane, Queensland, 1st, 5th, 6th and 7th Sept., 1927, Laidley, 22nd Nov., 1927, 2nd, 3rd, 5th, 6th January, 1928, and Gatton, Queensland, 29th August, 1928. Another ♀ was reared in the Laboratory at Brisbane, 11th Oct., 1927, from a mated pair. All the specimens were reared from a Pyrrhocorid bug, *Dysdercus sidae*.

The pupal characters are very similar to those of *Alophora* in that the posterior respiratory tubercles are very strongly produced and united only basally.

ALOPHORA AUREIVENTRIS Curran.

Bull. Ent. Res., xviii, 1927, 165.

There are before me six males and seven females of this species, all reared from *Dysdercus sidae*. The female was originally described as having broad yellowish pollinose bands on the bases of the abdominal segments, but that is not the case in the females at present before me. The pollinose bands are rather narrow, whitish or cinereous rather than yellowish and the fourth segment is almost wholly whitish or cinereous.

In the pupae there is a remarkable difference in the apparent lengths of the posterior spiracles, due, not to the actual length of these organs, but to the condition of the pupal skin. In one specimen the spiracles are almost wholly retracted, whilst a second has the pupal skin drawn out so that the spiracles project very strongly from a short pedicel and the normal wrinkling about their base is absent. It would be possible to draw certain conclusions from this variation but, inasmuch as the life history of the insect is to be dealt with elsewhere, I do no more than call attention to it.

Malloch has described several species of *Hyalomyia* from Australia, some of them falling within my conception of *Alophora*. I have separated the two genera on the presence of squamose hairs on the pleura of *Hyalomyia* and their absence in *Alophora*. If, as Malloch states, this is a sexual character, I can see no reason why the two genera should not be united, in which case the name *Alophora* would have precedence. The presence of more than one row of bristles or hairs on the front cannot be accepted as a generic character, since the distinction does not actually exist when a large number of species are examined. The Australian species of *Alophora* and *Hyalomyia* may be separated as follows:

1. Abdomen red 2
   Abdomen black 3
2. Wings streaked with white in the costal cell, along the third and fifth veins and in the apical cell ..... *aureiventris* Curran.
   Wings greyish yellow in front, paler behind ..... *rufiventris* Macquart.
3. Mesopleura with squamose hairs 4
   Mesopleura without squamose hairs 5
4. Hind femora with long, yellow bristly hair on basal four-fifths ..... *lepidophora* Malloch
   Hind femora wholly black-haired ..... *nigrihirta* Malloch.
5. Wings almost uniformly coloured, or with paler base and dark stigmal spot 6
   Wings with a pale brown cloud over the inner cross-vein and the costal cell brown ..... *costalis* Malloch.

6. Squamae whitish or yellowish 7
   Squamae brown ..... *nigrisquama* Malloch.
7. Apical cross-vein almost transverse ..... *lativentris* Malloch.
   Apical cross-vein forming an almost even bow with the last section of the fourth vein, the apical cell sharply pointed at its apex ..... *aureiventris* Curran.

PROSENA Serville.*

Key to the Oriental and Australasian Species of Prosena.

1. Scutellum wholly dull black 2
   Scutellum pale pollinose or pale in ground colour 4
2. Mesonotum with a broad, brown fascia behind the suture, otherwise pale pollinose (from posterior view) 3
   Mesonotum black vittate (*indecisa* Malloch?) ..... *vittata* Macquart.
3. Wings brownish on the apical half, paler brownish on basal half .. *argentata* Curran.
   Wings almost hyaline (Tasmania) ..... *rufiventris* Macquart.
4. Femora reddish or yellowish on at least the basal half 5
   Femora black 16
5. Abdomen without a median shining black vitta 6
   Abdomen with the median vitta shining black ..... *dorsalis* Macquart.
6. Cheeks wholly white pollinose, without a reddish-brown spot between the eye and oral margin 12
   Cheeks with a reddish-brown or dark spot extending from the eyes to the oral margin 7
7. Mesonotum with an incomplete brownish fascia behind the suture .... *bella* Curran.
   Mesonotum vittate 8
8. Tibiae brown 9
   Tibiae reddish; frontal vitta rusty-reddish (Australia) ..... *variegata* Curran.
9. Abdominal pollen tessellate 10
   Abdominal pollen not tessellate 11
10. Thorax black, the humeri yellow in ground colour (Tasmania) .. *dispar* Macquart.
    Thorax brownish-red in ground colour (Queensland) .... *Austrodexia taylori*, n. sp.
11. Thorax reddish in ground colour, grey pollinose, blackish or brownish-red vittate ..... *dimidiata*, n. sp.
    Thorax not vittate, blackish? in ground colour ..... *moluccana* Doleschall.
12. Legs long; abdomen black fasciate ..... *moluccana* Doleschall.
    Legs of normal length; abdomen not fasciate 13
13. Mesonotum with fine, yellowish hair ..... *sibirita* Fabricius.
    Mesonotum with only coarse black hair, except on the sides 14
14. Parafacials with distinct yellowish hair; front with black hair .... *facialis*, n. sp.
    Parafacials without any trace of hair; front with sparse yellowish hairs inwardly 15
15. Scutellum black, grey pollinose with dark border ..... *marginalis*, n. sp.
    Scutellum reddish in ground colour ..... *malayana* Tns.
16. Legs wholly black, pleura pale pollinose 17
    Tibiae reddish; mesopleura black pilose ..... *varia* Curran.
17. Mesonotum pale pilose; legs very long ..... *zonalis* Curran.
    Mesonotum black-haired 18
18. Scutellum wholly dark in ground colour 19
    Scutellum reddish ..... *scutellaris* Curran.
19. Mesopleura black pilose ..... *surda*, n. sp.
    Mesopleura pale yellow pilose ..... *nigripes* Curran.

PROSENA DISPAR Macquart.

Dipt. Exot., Suppl. iv, 1852, 203.—There is a female from Jenolan Caves, N.S.W. (J. C. Wiburd), which traces to *dispar* in the key. The species was originally described from Tasmania and the identification must be considered doubtful until the type has been examined.

PROSENA VARIA Curran.

Ann. Ent. Soc. Amer., xxii, 1929, 509.—One male, Jenolan Caves, N.S.W. (J. C. Wiburd).

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* *P. tenuis* Malloch and *parva* Malloch are not included.

PROSENA ARGENTATA Curran.

Ent. Mitt., xvi, 1927, 348.—♂ and ♀ from Herberton, Queensland, Dec., 1910, and Jan., 1911, in Wainwright collection.

PROSENA BELLA Curran.

Ent. Mitt., xvi, 1927, 347.—♂. Kuranda, Queensland (Dodd).

PROSENA DIMIDIATA, n. sp.

Very similar to *Austrodexia taylori* in structure, but with the wings brown on the apical half and the abdominal pollen not tessellate. Length, 11 to 13 mm.

♀. Head reddish, greyish-yellow pollinose; occiput black in ground colour, the pollen of the front with brown tinge, the frontal hair and occipital pile yellow. Front four-sevenths as wide as eye, with seven pairs of frontals, the upper pair divergent or reclinate, the two pairs of orbitals strong; ocellars long; outer verticals short; occipital cilia not extending to lower edge of eyes, several bristly black hairs near the vertex. Cheeks hardly one-third as wide as eye-height, with a few obscure yellow hairs near the anterior oral margin. Proboscis almost one half longer than head-height, brown, the broad base and the labella reddish Palpi and antennae reddish. Facial carina of moderate width, flattened or slightly grooved above. Mesonotum blackish or deep brown, the conspicuous vittae blackish, the pollen greyish. Scutellum reddish, with darker base, black haired, with three pairs of marginals, the apical pair cruciate, the pair of discals weak. Acrosticals 0–1; dorsocentrals 3–3; sternopleurals 1–1. Legs elongate, brown, the coxae and femora reddish, the posterior four femora brown apically. Wings cinereous-hyaline on basal half, brown apically. Squamae with brown tinge; halteres yellow. Abdomen with the apical half of the second and third and apical third of the fourth segment brownish or brownish-black, the second and following segments reddish basally and rather thickly grey pollinose, the pollen separated on the intermediate segments by a narrow black vitta and on the fourth by a very broad one. The hair is black dorsally, yellowish ventrally; first segment without marginals, second with one pair, third and fourth each with a row.

Holotype ♀ and two ♀ paratypes, Kuranda, Queensland, a paratype collected by F. P. Dodd, the others without collector's name. Type in the collection of the School of Public Health and Tropical Medicine, University of Sydney, paratype in American Museum of Natural History.

PROSENA FACIALIS, n. sp.

Related to *malayana* Townsend, from which it differs in having the frontal hair black, scattered and obscure, with pale yellow hairs on the parafacials. Length, 6·5 to 11 mm.

♂. Head yellowish, the occiput and upper part of the front black in ground colour, whitish pollinose. Front half as wide as eye, clothed with black hair; about ten pairs of frontals; ocellars long; outer verticals absent. The black occipital cilia in large specimens are usually two-rowed and extend well onto the cheeks, in small specimens more often in a single row and not extending across the cheeks. Occipital pile whitish. Cheeks half as wide as eye-height, with fine yellowish or fuscous hair near the anterior oral margin; parafacials with very fine scattered yellow hair on upper half. Proboscis brown or black, reddish basally, twice as long as head-height. Palpi and antennae reddish. Facial carina moderate in width, rather flattened. Thorax black, cinereous pollinose, the four narrow brown vittae well marked; scutellum varying from reddish to almost all black,

the apex always more or less reddish beneath the grey pollen; three pairs of marginals, the apical pair cruciate, and a pair of weak discals. Hair black, on the pleura fine and yellowish. Acrosticals 1–1; dorsocentrals 3–3 or 2–3; sternopleurals 1–1. Legs reddish, tarsi black, posterior tibiae and the apices of their femora usually with brown stain. Wings cinereous hyaline. Squamae with greyish tinge, their border more yellowish. Halteres yellow. Abdomen with the sides of the first three segments reddish, the third black on apical third, the basal two with a small posterior black spot on either side, the whole cinereous pollinose, the median vitta, apex of third segment and base of the fourth with more brownish pollen. Hair black, pale on ventral surface of first segment. First and second segments with pair of marginals, third and fourth with a row.

Holotype, ♂, Kodaikanal, French Indo China, May, 1913. Paratypes, 31 males from French Indo-China. Type in American Museum of Natural History.

PROSENA MALAYANA Townsend.

More than a dozen specimens from Java and various localities in Queensland. I believe that *doddi* is the same and have placed my specimens under *malayana*, describing those forms in which the face is distinctly haired as *facialis*.

PROSENA MARGINALIS, n. sp.

Thorax black, cinereous pollinose; abdomen reddish-yellow with black median vitta and cross-bands; femora reddish. Length, 8·5 to 9·5 mm.

♂. Head yellow, white pollinose, the upper fourth of the front and the occiput black in ground colour; front slightly more than two-fifths as wide as greatest width of eye, with about nine pairs of bristles; frontal vitta pale orange; outer verticals scarcely differentiated; the single row of black occipital cilia does not reach the lower border of the eyes; occiput and cheeks whitish-haired, a few hairs near the oral margin; cheeks three-eighths as wide as eye-height, without dark band. Proboscis somewhat more than one-half longer than head-height, reddish on basal third. Antennae reddish-yellow, the arista reddish-brown. Facial carina of moderate width, not grooved. Thorax thickly cinereous pollinose, the vittae narrow and moderately distinct, each hair arising from a tiny dark puncture. Pleura yellow-haired, mesonotum and scutellum black-haired, the border of the scutellum dull black. Acrosticals 1–1; dorsocentrals 3–3; sternopleurals 1–1; scutellum with three pairs of marginals, the apical pair weaker and cruciate, and a pair of discals. Legs reddish, tarsi black, posterior femora brownish on apical fourth; posterior four coxae black, grey pollinose. Wings cinereous hyaline; squamae white; halteres yellow. Abdomen with a broad median vitta, apical fourth of third segment and whole of the fourth, black, the apex of the second segment very narrowly blackish, more conspicuously so laterally, the whole abdomen cinereous pollinose with the apices of the intermediate segments less thickly so, the pollen slightly tessellate. First segment with weak, second with pair of strong marginals, the third and fourth with row. Abdomen black-haired except at base of under side.

♀. Very similar, but the abdomen more oval. Front three-fourths as wide as eye, widening anteriorly; two pairs of orbitals; facial carina sometimes weakly grooved. Fourth abdominal segment mostly reddish in ground colour, black dorsally on the basal half of the disc.

Holotype, ♂, Brisbane, Queensland, 27th Nov., 1925; allotype, ♀, Brisbane, 3rd Dec., 1925. Paratypes, 8 ♂, Brisbane, 24th October, 1926, 27th Nov., 1925, and 10th Dec., 1925; 2 ♀, Sherwood, Queensland, 1st Dec., 1924, all collected by Mr.

J. Mann. Type specimen in Mann collection, paratypes in American Museum of Natural History.

This species looks very like a small example of *malayana* Townsend, but the blackish-margined scutellum is very distinctive.

PROSENA SURDA, n. sp.

Resembles *marginalis*, but is at once distinguished by the wholly blackish legs. Length, 6 to 10 mm.

♂. Black, the abdomen with reddish-yellow markings. Head black, grey pollinose, the face, cheeks, antennae and palpi reddish. Front one-fifth as wide as greatest width of eye, with twelve to fourteen pairs of frontals and a few black hairs; ocellars long; outer verticals absent; occipital cilia extending to the black-haired cheeks; occipital pile with yellow tinge. Cheeks two-sevenths as wide as eye-height, usually without hairs near anterior oral margin. Proboscis black, more or less reddish basally, twice as long as head-height. Arista brownish-red, the rays brown. Facial carina rather narrow, rounded. Thorax and scutellum densely grey pollinose, usually with little trace of slender dark vittae without magnification. Hair black. Acrosticals 1–1; dorsocentrals 3–3; sternopleurals 1–1. Scutellum with three pairs of marginals, the apical pair cruciate, and usually a poorly differentiated pair of discals. Legs black, of ordinary length, the knees more or less reddish. Wings cinereous hyaline, more or less brownish tinged in front. Squamae whitish. Halteres yellow. Abdomen with a median vitta which is usually quite broad, the apices of the segments rather narrowly and the whole of the fourth segment black in ground colour, the whole pollinose, the pale portions and basal half or more of the fourth segment with greyish, the remainder with brownish pollen. Hair black, pale only at base of under surface. First and second segments with pair of marginals, the third and fourth with row.

♀. Front five-eighths as wide as eye, rather ochreous pollinose, with five pairs of frontals, the upper pair divergent, and two pairs of orbitals; outer verticals scarcely differentiated; dorsocentrals 2–3. Abdomen reddish, the broad apices of the first three segments more or less blackish or brownish, the fourth segment brownish on basal half; no median vitta; pollen somewhat tessellate; first segment without marginals.

Holotype ♂, allotype ♀, and ten paratypes (♂), Kuranda, Queensland (F. P. Dodd), forwarded by Mr. Colbran Wainwright. Types in collection of Mr. C. J. Wainwright.

This species resembles *malayana* Townsend, but the black pilose pleura at once distinguishes it. Its form is more slender than in that species and also than is the case with *marginalis* Curran. There is a greater variation in size than has been noted for most of the other species belonging to the genus.

AUSTRODEXIA Malloch.

PROC. LINN. SOC. N. S. WALES, lv, 1930, 122.

All the characteristics of *Prosena*, but the proboscis is not or only slightly longer than the height of the head. The palpi are short, never longer than twice the greatest width of the proboscis; propleura and prosternum bare, infrasquamal setulae and the posterior sublateral bristles absent. None of the species before me have an appendage at the bend of the fourth vein, but this character may be present. Most of the species described from Australia and Tasmania as belonging to the genus *Dexia* belong here or to *Lasiocalypter*.

Genotype, *Austrodexia setigera* Malloch.

The following species are before me:

Table of Species.

1. Femora black except at the apices 2
   Femora reddish, darker toward the apices ..... *taylori*, n. sp.
2. Palpi black; thorax of ♂ silvery-white from anterior view .... *longipes* Macquart.
   Palpi reddish or brownish-red 3
3. Abdomen black 4
   Abdomen reddish with median black vitta and apex ..... *setigera* Malloch.
4. Mesopleura almost all black-haired ..... *unipuncta* Malloch.
   Mesopleura with bright yellow hair 5
5. Tibiae and the broad apices of the femora reddish (♂) ..... *longipes* Macquart.
   Legs normally all black or brownish 6
6. Anterior cross-vein conspicuously clouded with brown ..... *communis* Malloch.
   Anterior cross-vein not clouded (♀) ..... *longipes* Macquart.

Austrodexia unipuncta Malloch.

Proc. Linn. Soc. N. S. Wales, lv, 1930, 126.

Four ♂, one ♀, Katoomba, N.S.W., January, 1921 (Dodd, jnr.); ♀ "N.S.W."; ♂, ♀, Jenolan Caves, N.S.W. (J. C. Wiburd).

Austrodexia setigera Malloch.

Proc. Linn. Soc. N. S. Wales, lv, 1930, 124.

Four ♂, Herberton, Queensland, November, 1911; two ♂, Herberton, December, 1910 (F. P. Dodd).

Austrodexia communis Malloch.

Proc. Linn. Soc. N. S. Wales, lv, 1930, 125.

Very similar to *unipuncta*, but the pleura are entirely pale-yellowish pilose, etc. Length 8 to 12 mm.

♂. Differs from *unipuncta* as follows: front one-fourth as wide as either eye; parafrontals brownish-pollinose on upper third or more; mesonotum a little more evenly and densely cinereous-pollinose, the dark vittae very narrow and brownish; two intra-alar bristles; pleura wholly pale-yellow pilose; legs, wings and abdomen the same; posterior tibiae with a strong posterodorsal bristle near the middle.

Three ♂, N.S.W. (Hy. Edwards Coll.); two ♂ from Sydney, N.S.W., Feb., 1928 (F. H. Taylor); one ♂, Brisbane, Queensland, 23.10.1926 (J. Mann).

Austrodexia taylori, n. sp.

Rusty-brownish with yellowish-tinged pollen; legs long; wings with brown tinge, especially marked along the veins; thorax vittate. Length, 12 to 14 mm.

♀. Head yellowish in ground colour, the parafrontals and occiput brown, whitish pollinose. Front slightly more than half as wide as greatest width of eye, the vitta mostly brown; nine pairs of frontals, the upper pair reclinate; ocellars long, outer verticals stout; the black occipital cilia extend to the lower edge of the eyes and there are a few black hairs behind them near the vertex; occipital pile pale yellowish; cheeks about three-sevenths as wide as eye-height, with a few yellowish hairs near the oral angles; proboscis reddish, shorter than height of head; palpi and antennae reddish. Facial carina broad, shallowly grooved. Frontal hair yellow. Cheeks with reddish-brown stripe from eye to oral margin. Mesonotum and scutellum yellowish-grey pollinose, the pleura cinereous; dorsum black-haired, the pleura yellow-pilose. Acrosticals 1–1; dorsocentrals 2–3; sternopleurals 1–1. Scutellum with three pairs of marginals, the apical pair cruciate, and a pair of weak discals. Legs brown, an obscure median band on the tibiae, the femora and coxae reddish. Wings with strong yellowish-

brown tinge. Squamae luteous greyish. Halteres yellow. Apices of abdominal segments narrowly blackish, the abdomen with tessellate yellowish-tinged pollen. First and second segments with pair of marginals, third and fourth with row.

♂. Front three-fourteenths as wide as either eye, the vitta almost obsolete above; pale hair long; outer verticals hair-like; no setae behind the black occipital cilia; proboscis brown, the third antennal segment mostly brownish; pollen of thorax and abdomen more cinereous and less tessellate on the abdomen, which is more slender and tapering and has the first segment and under surface pale-pilose and a median dorsal vitta much more pronounced. The posterior legs are very long.

Holotype ♀, allotype ♂ and paratype ♀, Kuranda, Queensland; ♀, Townsville, Queensland (F. P. Dodd); 2 ♂, Roberts Plateau, Macpherson Range, Queensland, February–March, 1929 (Dr. A. J. Turner). Holotype in the collection of the School of Public Health and Tropical Medicine, University of Sydney, paratype in American Museum of Natural History, the allotype in the collection of Mr. C. J. Wainwright.

This species is rather intermediate between *Austrodexia* and *Prosena*. It has the proboscis either a little longer than the head-height, or a little shorter, depending upon whether or not the labellae are folded back or projecting.

Austrodexia longipes Macquart.

Dexia longipes Macquart, *Dipt. Exot.*, Suppl. 1, 1846, 187.—*Rhyncodexia longipes* Malloch, Proc. Linn. Soc. N.S.W., lv, 1930, 119.

I have before me four males and ten females which I believe to be this species. In the male the mesonotum is white-pilose and, when viewed from in front, appears silvery owing to the whitish pollen on the mesonoum; pleura and abdomen yellow-pilose; from dorsal view the mesonotum appears yellowish-pollinose and quite dull. In the female the pollen is cinereous-yellow and the dark mesonotal vittae are very distinct. The abdominal pollen is strongly tessellate; wings cinereous hyaline, slightly tinged with yellow; legs black. In the female the pleura are white-pilose, the mesonotum mostly black-haired.

♂, 8 ♀, Jenolan Caves, N.S.W. (J. C. Wiburd); ♀, Broken Hill, N.S.W. (D. H. Wallace); 3 ♂, 1 ♀, Katoomba, N.S.W. (Dodd, junr.).

Lasiocalypter Malloch.

Proc. Linn. Soc. N. S. Wales, lv, 1930, 119.

Similar to *Prosena*, but the second section of the proboscis is always shorter than the height of the head; much more closely related to *Austrodexia*, but distinguished by having the lower lobe of the squamae pilose on the disc of the outer posterior area. The general characters of the three genera are the same: all have the face strongly carinate, arista long pilose; parafacials bare; propleura and prosternum bare, infrasquamal setulae absent; legs elongate and the abdomen of the female shorter and broader than in the male. The bristles are long and slender, shorter and coarser in the female.

Genotype, *L. flavohirta* Malloch.

The three genera are separable as follows:

1. Squamae bare except on the rim 2
   Squamae pilose on outer posterior surface of the disc ..... *Lasiocalypter* Malloch.
2. Apical section of proboscis very much longer than the head-height .....
   ..... *Prosena* St. Fargeau et Serville.
   Apical section of the proboscis at most scarcely longer than the head-height .....
   ..... *Austrodexia* Malloch

Key to the species of Lasiocalypter.

1. Pleura wholly yellow-haired 3
   Mesopleura black-haired 2
2. Pile of the squamae black ..... *nigrihirta* Malloch.
   Pile of the squamae yellow ..... *basalis*, n. sp.
3. Mesonotum of male black-haired, tibiae black ..... *apicalis*, n. sp.
   Mesonotum of male mostly yellow-haired; tibiae reddish .....
   ..... *tessellata* Macquart; *flavohirta* Malloch.

LASIOCALYPTER NIGRIHIRTA Malloch.

PROC. LINN. SOC. N. S. WALES, lv, 1930, 119.

Two ♂, two ♀, Jenolan Caves, N. S. Wales (J. C. Wiburd).

LASIOCALYPTER BASALIS, n. sp.

Black; wings yellowish basally; squamae yellow. Length, 8 mm.

♂. Middle of face whitish, the sides and cheeks reddish in ground colour; head whitish pollinose. Front less than one-fifth as wide as greatest width of eye; frontal vitta obsolete above, wide below; eleven or twelve pairs of frontals and a much finer and shorter bristle between each of the long ones in the rows; hair on the parafrontals sparse and white. Occiput and cheeks pale-yellow pilose, the black occipital cilia expanding into several rows behind the lowest third of the eyes. Cheeks three-eighths as wide as eye-height; only one or two very short and weak bristles above the vibrissae; carina broad, not sulcate. Palpi dull reddish. Antennae reddish, the third segment slightly darkened on the apical half, almost three times as long as the second; arista ferruginous basally, the rays long and black. Thorax thickly cinereous-pollinose, the dark vittae narrow, distinct on the anterior half. Hair black, yellow on the lower half of the pleura. Acrosticals 1–2; dorsocentrals 3–3; intra-alars 2; three pairs of marginal scutellars, the apical pair more or less cruciate, the hair on the disc long; sternopleurals 1–1. Legs black; coxae and the base of the femora yellow-haired; pulvilli short. Wings tinged with brown on apical half, with luteous basally. Squamae and halteres yellow. Abdomen black, cinereous-pollinose, a median vitta and the rather broad apices of the segments black; pollen tessellate on both the dorsum and venter; hair black, yellow on the under surface except apically. First, second and fourth segments each with a pair of marginals, the third with a row; second and third segments each with a pair of discals.

Type ♂ and paratype, Roberts Plateau, Macpherson Range, Queensland, Feb.–March, 1929 (Dr. A. J. Turner), in collection of the School of Public Health and Tropical Medicine, University of Sydney.

LASIOCALYPTER APICALIS, n. sp.

Black; mesopleura black-pilose; apex of the wing with a very broad, oblique blackish infuscation. Length, 8 to 9 mm.

♂. Head black, white-pollinose, the face and cheeks reddish or reddish-yellow in ground colour. Front one-fifth as wide as greatest width of either eye, the blackish frontal vitta obsolete above. About twelve pairs of frontals and a long black hair between the bristles in the rows; very few hairs outside the rows; ocellars long. Pile of the occiput and cheeks yellowish; the black occipital cilia expand to form three irregular rows behind the lowest third of the eyes and the upper part of the cheeks. Cheeks somewhat less than half as wide as the eye-height. Two or three short bristles above the vibrissae. Palpi short, reddish. Antennae reddish, the third segment usually blackish on the apical half; arista reddish with brown base and long blackish rays. Thorax densely cinereous-

pollinose, the narrow, dark vittae distinct; hair black, on the pleura wholly yellow. Acrosticals 1–1; dorsocentrals 3–3; intra-alars 2, the anterior one fine; three pairs of marginal scutellars, the apical pair cruciate; sternopleurals 1–1. Legs black; coxae and bases of the femora yellow-pilose. Wings cinereous-hyaline, with a broad blackish cloud extending from the apical third of the wing to or beyond the apex. Squamae cinereous-yellow; with yellow pile; halteres yellow. Abdomen black cinereous-pollinose, a narrow median vitta and the apices of the segments dark. Hair black, yellow on the first segment and the venter. First and second segments each with a pair of marginals, third and fourth each with a row; second to fourth segments each with one or two irregular pairs of discals.

♀. Front a little more than half as wide as greatest width of either eye; frontal vitta slightly wider than either parafrontal; six or seven pairs of frontals, two pairs of orbitals and a very few scattered black hairs on the front; outer verticals long; dark abdominal fasciae broader.

Type ♂, allotype ♀ and 2 ♂, 7 ♀, Jenolan Caves, N.S.W. (J. C. Wiburd). Types in the collection of the School of Public Health and Tropical Medicine, University of Sydney.

Lasiocalypter tessellata Macquart.

Dexia tessellata Macquart, *Dipt. Exot.*, Suppl. iv, 1852, 202 (229).—*L. flavohirta* Malloch, Proc. Linn. Soc. N.S.W., lv, 1930, 121.

Black, with cinereous-yellow pollen, the apices of the femora and the tibiae reddish; mesonotal vittae distinct; a median abdominal vitta and the segmental apices darker. The thorax is wholly clothed with yellowish hair in the male, but in the female it is mostly black on the mesonotum and scutellum. Length, 10 to 12 mm.

In general this species is similar to the others in chaetotaxy, etc., but it is a little more robust. It fits Macquart's description better than any of the others and I have tentatively determined it as his species.

Three ♂ and two ♀ from N.S.W.

Australotachina, n. gen.

A peculiar genus resembling some of the species of *Calliphora* and with very large hypopygium.

Head at oral margin six-sevenths as long as high, the face almost perpendicular, the lower half strongly produced; no facial depression, the median part visible in profile on its whole length; parafacials narrow; front very narrow, the upper half only a little wider than the ocellar triangle, the anterior half triangular; ocellar bristles strong; two pairs of frontals below the base of the antennae; hair of the head black, the middle of the occiput with sparse yellow pile on the lowest two-thirds; cheeks a little more than three-sixteenths as wide as eye-height, clothed, except on the upper edge, with sparse, coarse black hair. Vibrissae situated more than the length of the second antennal segment above the oral margin, the ridges with three or four bristles immediately above them. Palpi cylindrical, black-haired. Antennae short, extending only three-fifths the distance to the oral margin; third segment two-thirds longer than the second, elongate oval; arista short pubescent on the basal half, the basal fifth swollen. Eyes bare. Proboscis short. Acrostical bristles 2–3; dorsocentrals 3–4; posterior sublateral absent; two intra-alars; four pairs of strong marginal scutellars, the apical pair cruciate; sternopleurals 2–1; propleura and prosternum bare; infrasquamal setules present. Anterior femora with a row of posteroventral bristles; their tibiae with

one posterior and one anterodorsal bristle; middle tibiae with two anterodorsal, one anteroventral and two posteroventral bristles; posterior tibiae with two antero- and postero-dorsal bristles and three anteroventrals. Pulvilli elongate. Wings with the apical cell narrowly open, ending a little before the apex; bend of fourth vein not acute; posterior cross-vein joining fourth vein beyond the middle of its penultimate section; two bristles at the base of the third vein. Abdomen egg-shaped, moderately convex, the hypopygium large. First segment without dorsal bristles, the second with a row of marginals; third and fourth each with a row of marginals and discals as well as a few scattered bristles, the hair all erect or nearly so. First segment of the hypopygium large, with a row of bristles apically, the second segment still larger and with bristles on the apical half, the following part with short, appressed hair; posterior forceps very large, broad and moderately convex, enclosing the genital organs, the basal half with rather dense appressed hair. The lobes of the fifth sternite extend, as large triangles, to close the sides of the pocket formed by the hypopygium. The fourth sternite is apparently linear or even absent, but I am unable to see this part.

Genotype, *Australotachina calliphoroides*, n. sp.

AUSTRALOTACHINA CALLIPHOROIDES, n. sp.

Black, the thorax and abdomen with metallic green or blue reflections. Length, 5·5 to 7 mm.

♂. Head with moderately thick dull-cinereous pollen, the parafacials and parafrontals cinereous-white. Eight to ten pairs of fine frontal bristles, the upper ones becoming hair-like, the hair situated in a row very close to the frontals. Outer vertical very weak; occipital cilia moderately long. Palpi black; antennae black. Thorax thinly cinereous-pollinose, the vittae very indistinct; sometimes a distinct metallic-green reflection. Hair wholly black, sub-erect, long on the apical half of the scutellum; pteropleural bristle rather weak. Legs black. Wings brownish; squamae yellowish-tinged. Halteres with black knob. Abdomen rather thinly cinereous-pollinose, the first segment wholly and the apex of the second darker; with strong metallic-greenish or bluish reflections. Hair erect or nearly so.

♀. Front almost half as wide as greatest width of either eye, gradually widening anteriorly; two pairs of frontals; outer verticals almost as long as the verticals; first and second abdominal segments without dorsal bristles, the third to fifth each with a row of marginals. The fifth segment is very narrow; sixth divided in the middle dorsally, the opening at the apex V-shaped, at the lower ends connected on either side with a large, elongate-oval, pad-like lobe corresponding to the lobes in the male; these lobes are very rough interiorly and evidently setulose, exteriorly with ordinary hair.

Type ♂ and two paratypes, Kuranda, Queensland, in Deutsches Entomologisches Museum; allotype and 9 ♂ paratypes, Kuranda, 1910 (F. P. Dodd), in C. J. Wainwright collection; paratypes in American Museum of Natural History.

EIPOGONOIDES, n. gen.

Related to *Eipogona* Rondani, but the eyes are sparsely pilose; differs from *Chaetosturmia* Villeneuve, from Africa, in its smaller size, shape of head and the presence of only three sternopleurals.

Face not retreating, sub-carinate, the oral margin not produced; parafacials with hairs on upper two-thirds or more; front wide in both sexes, with a secondary row of frontals in the ♂ and partial row in the ♀. Ocellars long; outer verticals well developed in both sexes; cheeks one-seventh as wide as eye-height; eyes

sparsely haired; proboscis short; palpi normal. Antennae arising about the middle of the eyes and reaching three-fourths the distance to the oral margin. Bristles of thorax complete; acrosticals 3–3; dorsocentrals 3–4; posterior sublateral present; supra-alars 3; sternopleurals 2–1; 3 pairs of marginal scutellars, the apical pair weak and either divergent or decussate, a weak pair of discals. Propleura bare; infrasquamal setulae absent. Legs normal; middle tibiae with one strong and two or three poorly differentiated anterodorsal bristles; pulvilli small in both sexes. Wings normal, the apical cell open, ending moderately close to the apex of the wing; posterior cross-vein joining penultimate section of fourth vein beyond the middle; third vein with two or three bristles at the base. Abdomen short oval, without true discals on the intermediate segments but with rather coarse, erect hair; first and second segments each with a pair of marginals, third with a row, the fourth with bristles except apically.

Genotype, *Eipogonoides ruficornis*, n. sp.

Eipogonoides ruficornis, n. sp.

Antennae reddish-yellow; legs reddish, the tarsi black. Length 5·5 to 6 mm.

♂. Face and cheeks reddish in ground colour, the head otherwise blackish, wholly covered with yellowish pollen, the parafrontals less thickly so. Front almost three-fourths as wide as either eye, slightly widening anteriorly; parafrontals a little wider than the brownish-red frontal vitta; a row of about nine frontals on either side and a secondary row outside these, the hair rather coarse and erect; lower three frontals below the base of the antennae, the upper three or four reclinate; outer verticals three-fourths as long as verticals; occiput, cheeks and parafacials with short, fine black hair, the latter with hair on their whole length, narrower than the third antennal segment and narrowing below. Proboscis brown, the labellae and palpi reddish-yellow. Vibrissae situated only a little above the oral margin, the ridges with about five bristles on the lowest third. Antennae orange; third segment a little more than twice as long as the second, rather angulate at the upper apex; arista brown, thickened on the basal two-fifths, microscopically pubescent. Thorax black or blue-black, ashy pollinose, in some lights showing four dark vittae; scutellum with the apex more or less reddish. Legs, including the coxae, reddish; tarsi black or brown. Wings cinereous hyaline, somewhat yellowish basally. Squamae whitish, with yellowish tinge; halteres reddish. Abdomen black, evenly clothed with brownish-cinereous pollen, which may have a yellowish cast in some lights.

♀. Front as wide as either eye, with two pairs of orbital bristles; abdominal pollen cinereous; abdominal hair more appressed.

Type ♂, allotype ♀, and one paratype of either sex, New South Wales, 18.10.1916 (No. 62, W. W. Froggatt), ex Saunders case moth.

Thrycolyga Rondani.

There are before me two species of *Thrycolyga* from Queensland, both very similar in appearance but displaying marked genitalic differences in addition to differences in the number of bristles on the tibiae and the colour of the frontal pollen. One of these I have determined as *flaviceps* Macquart, whilst the other is described as new. Both species have only very short hair on the eyes, and at first glance would appear to belong to the genus *Exorista* Meigen in which the eyes are bare. Malloch records *T. sorbillans* from Queensland and states that *Podomyia* is a synonym of this genus. In *Podomyia* the eyes are entirely bare, the genus differing from *Sturmia* only in having the facial ridges bristled on more than the lower half.

Key to males of Thrycolyga *recorded from Australia.*

1. Posterior forceps with ordinary hair 2
   Posterior forceps on the posterior or basal half bearing very dense yellow hair ..... *sorbillans* Wiedemann.
2. Penis short and more or less angled; parafrontals bright yellow pollinose ..... *curriei*, n. sp.
   Penis long, slender, curved; parafrontals cinereous-pollinose; middle tibiae with three anterodorsal bristles ..... *flaviceps* Macquart.

THRYCOLYGA FLAVICEPS Macquart. Fig. 1.

Exorista flaviceps Macquart, *Dipt. Exot.*, Suppl. 2, 1847, 83 (67).

♂, Biloela, Q., 8.2.1925 (F.G.H.), ex *Conogethes punctiferalis*; ♂, Yanco, N.S.W., 1916.

Whether or not this is *flaviceps* will probably never be settled, since the description would fit a great many species of Tachinids and the type is probably lost. However, Brauer and Bergenstamm have placed the species in *Thrycolyga*, and the specimens agree with the description much better than the second species before me. The species is, in addition, widely distributed.

THRYCOLYGA CURRIEI, n. sp. Fig. 2.

Black, the cinereous pollen more or less tinged with yellow; palpi reddish-yellow; scutellum brownish-yellow, darker basally. Length, 7·5 to 13 mm.

♂. Head apparently brownish-red in ground colour, the occiput black, clothed with white pollen, the frontal pollen and that on the upper part of the parafacials and occiput bright yellow. Front with seven or eight pairs of bristles, the upper three pairs reclinate, the lower three below the base of the antennae; frontal vitta brown, narrowed above, not as wide as parafrontal, the front only a little narrower than the greatest width of either eye. Vertical bristles directed backwards; outer

1.—*Thrycolyga flaviceps* Macquart. 2.—*T. curriei*, n. sp.

verticals absent; occiput thickly white-pilose; occipital cilia in a single row extending to the cheeks; cheeks almost one-fourth as wide as eye-height, with fine black hair which becomes pale on the anterior part. Parafacials wider than third antennal segment, of almost equal width throughout. Vibrissae situated above the oral margin; about five bristles on the lower fourth of the facial ridges; depression sub-carinate. Antennae black, the second segment mostly reddish, somewhat elongate; third segment two and one-half times as long as the second; arista thickened on basal half. Palpi reddish-yellow. Eyes with sparse, short hair. Thorax thickly pollinose, with four sub-shining black vittae; bristles complete; sternopleurals 2–1, the lower one small. Scutellum with three pairs of strong marginals and a weak, convergent apical pair. Legs black; middle tibiae with two anterodorsal bristles on the basal half; pulvilli long, yellowish-brown; posterior tibiae sub-ciliate. Wings cinereous-hyaline, tinged with luteous basally; squamae cinereous-yellow; halteres reddish. Abdomen shining black, a little more than

the basal half of the second to fourth segments cinereous-pollinose, the pollinose bands on the second and third segments somewhat narrowed on either side of the middle and more or less distinctly interrupted by a slender median line. First and second segments each with a pair of short marginals, the third and fourth with row of strong ones. Hair subappressed except on the fourth segment. Fourth sternite convex apically and slightly produced downwards. Posterior forceps united to form a long, slender beak, not unusually hairy; penis short and thick (fig. 2).

♀. Front wider, white pollinose, only moderately yellowish above; two pairs of orbitals; outer verticals strong; cheeks with less abundant, coarser black hair, and narrower. Abdomen with whitish-cinereous pollen, the marginal bristles on the second segment long and strong; squamae more whitish.

Type ♂, Lawnton, Queensland, 25.9.1927 (G. A. Currie); allotype ♀, same data, both ex cutworm; paratypes, ♂, ♀, Biloela, Queensland, 11.2.1927 and 20.2.1927, ex *Heliothis obsoleta*. The ♂ paratype has been attacked by pests and lacks the genital organs.

There may be some doubt as to this species belonging to the genus *Thrycolyga* because of the presence of only three bristles below the base of the antennae, but the lowest one is situated only a little above the middle of the parafacial.

Zenillia Desvoidy.

Of the species of *Zenillia* (*Exorista* auct. and *Eurigaster*, pt.), described from Australia, I have been able to recognize only one, and even this may be incorrectly determined. The following key separates the species before me.

Table of Species.

1.	Tibiae black or brownish-red	2
	Tibiae clear reddish	*lata* Macquart
2.	Palpi reddish	3
	Palpi black	*nitidicauda*, n. sp.
3.	Sternopleurals 1-1	4
	Sternopleurals 2-1 or 2-2	7
4.	Epaulet black or brown	5
	Epaulet yellowish or reddish	10
5.	Middle tibiae with only one anterodorsal bristle	6
	Middle tibiae with two or three anterodorsal bristles	*doddi*, n. sp.
6.	Pollen on the fourth abdominal segment apparently very broadly interrupted	*hardyi*, n. sp.
	Pollen on the fourth abdominal segment forming an entire band	*murina*, n. sp.
7.	Sternopleurals 2-1	8
	Sternopleurals 2-2	11
8.	Mesonotum with ordinary blackish vittae, not fasciate	9
	Mesonotum with a transverse black spot behind the suture	*picta*, n. sp.
9.	Scutellum entirely black in ground colour	*tristis*, n. sp.
	Scutellum mostly reddish in ground colour	*sapiens*, n. sp.
10.	Anterior tibiae with two posterior bristles	*noctuae*, n. sp.
	Anterior tibiae with only one posterior bristle	*cosmophilae*, n. sp.
11.	Ocellars absent	*taylori*, n. sp.
	Ocellars long and strong	*quadrisetosa*, n. sp.

Zenillia murina, n. sp.

Resembles the African *Zenillia evolans* Wiedemann, but is at once distinguished by the very weak ocellar bristles and the presence of but one posterior bristle on the anterior tibiae. I do not know whether this species and *cosmophilae* should be retained in *Zenillia*, inasmuch as they lack the second bristle on the anterior tibiae. This is usually a very reliable character, and even though the resemblance of these species to the African forms is most remarkable it might well be that they should be separated generically. Length, 10 to 11 mm.

♂. Head black, the parafacials and anterior oral margin reddish, the whole densely white-pruinose, the front tinged with yellow above. Front almost or quite half as wide as greatest width of either eye, widening on the anterior two-thirds; frontal vitta blackish, narrower than either parafrontal; about twelve pairs of frontals, the lowest five pairs situated below the base of the antennae; the upper two pairs reclinate; immediately outside each row of frontals some bristly hairs and outside these scattered, short black hair; ocellars weak. Occipital cilia black; the pile white; cheeks about one-tenth as wide as eye-height, black-haired. Parafacials wider above than the third antennal segment, narrowed below; vibrissae level with the anterior oral margin; four or five fine bristles immediately above them on the facial ridges. Palpi reddish. Antennae black, the third segment three times as long as the second; arista slender, thickened on the basal two-fifths. Eyes with pale yellow pile. Thorax thickly cinereous-pollinose, the four dark vittae moderately distinct. Chaetotaxy normal; sternopleurals 1–1. Scutellum yellowish-red, with four pairs of marginals, the apical pair cruciate. Hair wholly black. Legs black; middle tibiae with a single anterodorsal bristle; posterior tibiae closely ciliate, the anterior tibiae with only one posterior bristle; pulvilli elongate. Wings cinereous-hyaline, tinged with luteous basally; squamae and halteres yellowish. Abdomen black, cinereous-pollinose, the apical third of the second to fourth segments and an obscure median vitta, bare or nearly so, the pollen inclined to be tessellate. First and second segments each with a pair of marginals, the third and fourth each with a row, the fourth with scattered erect bristles on whole dorsal surface.

Type ♂, Wee Waa, N.S.W., 14.10.1908, ex *Darala* sp.?, in British Museum of Natural History; paratypes, 2 ♂, Kuranda, Queensland (F. P. Dodd), in collection of Mr. C. J. Wainwright and American Museum of Natural History.

ZENILLIA NOCTUAE, n. sp.

Very similar in appearance to the African *Z. illota* Curran and differing only in having the shining apices of the segments broader, smaller size, and different posterior spiracles in the pupae. Black, the palpi and scutellum reddish, the antennae sometimes reddish basally; pollen cinereous. Length, 8 to 9 mm.

♂. Parafacials reddish in ground colour. Head silvery-white pollinose, the frontal vitta black, narrower than either parafrontal, widening slightly anteriorly. Front two-thirds as wide as greatest width of either eye; seven to nine pairs of frontals, the lower two pairs situated below the base of the antennae, the upper two pairs reclinate; hair short and not abundant; ocellars long, the ocellar triangle more or less yellow-pollinose; outer verticals absent; occipital cilia long and slender, in a single row; pile of occiput white. Cheeks not wider than one-tenth the height of either eye, with sparse, black hairs. Vibrissae situated almost on a level with the oral margin and only two or three weak bristles on the ridges above them; parafacials not as wide above as the width of the third antennal segment, strongly narrowing below. Palpi reddish. Antennae black; second segment sometimes largely reddish; third segment about three times as long as the second, convex apically; arista somewhat thickened on the basal two-fifths. Eyes white-pilose. Thorax black, thickly cinereous-pollinose, the dark mesonotal stripes weakly developed; chaetotaxy typical; four pairs of marginal scutellars, the apical pair strong and cruciate; sternopleurals 1–1. Hair wholly black. Scutellum reddish-yellow in ground colour, black basally. Legs black; middle tibiae with a single anterodorsal bristle; posterior tibiae evenly ciliate; pulvilli short, greyish-brown. Wings cinereous-hyaline, tinged with luteous basally; third

vein with three bristles at the base. Squamae yellowish-white; halteres reddish. Abdomen black, cinereous-pollinose, the first segment wholly, the apical third of the three following and an obscure median vitta on the second and third segments, bare; sides of second segment sometimes broadly reddish basally. First and second segments each with a pair of marginals, the third and fourth with a row, the fourth with a row of discals and with bristly, erect hair.

♀. Front with two pairs of orbitals; outer verticals well developed, otherwise as in the male.

Type ♂, ex cutworm, Lawnton, Queensland, 25.11.1927; allotype ♀, Biloela, Queensland, 12.2.1927, ex *Heliothis obsoleta*; paratypes, Biloela, 14.2.1927 (G. A. Currie); ♂, Queensland, 7.7.1924, ex *Cosmophila flava*; ♀, Darwin, N. Territory, 23.2.1914 (G. F. Hill); 2 ♂, 1 ♀, Brisbane, Queensland (Dr. A. J. Turner); ♂, Magnetic Is., Queensland, Jan., 1929 (J. W. Fielding); ♀, Palm Island, Queensland (Mrs. F. H. Taylor); ♀, Eungella, Queensland, Oct., 1928 (Dr. A. J. Turner).

Zenillia cosmophilae, n. sp.

This species so closely resembles *noctuae*, n. sp., that I at first considered the specimens as all belonging to one species. In view of the similarity in appearance, it is only necessary to point out the differences between the two.

In *cosmophilae* the parafrontals of the male are usually more or less yellowish-pollinose. The outstanding difference is to be found in the length of the pulvilli: in this species they are very long and of a cinereous-white colour whilst *noctuae* has them short and greyish-brown. The females of the two species are more difficult to separate, but the yellow or yellowish-tinged frontal pollen, and single posterior bristle on the anterior tibiae, is typical of *cosmophilae*, whilst *noctuae* has the frontal pollen yellow only on the ocellar triangle and the anterior tibiae bears two posterior bristles. The length is between 8·5 and 9·5 mm.

Type ♂, Queensland, 7.7.1924, ex *Cosmophila flava*, in British Museum of Natural History. Allotype ♀; paratypes, 2 ♂ and one ♀, Kuranda, Queensland, Sept., 1910 (F. P. Dodd), in collection of Mr. C. J. Wainwright and the American Museum of Natural History; ♂, ♀, Palm Island, and 2 ♂, Watten (Mrs. F. H. Taylor); ♂, Mt. Molloy, ♂, Townsville, and 2 ♂, Cairns (F. H. Taylor); the latter reared from *Cirphis unipuncta*; ♂, ♀, Brisbane, in house, Sept., 1929 (Dr. A. J. Turner).

Zenillia hardyi, n. sp.

Black, the abdomen largely reddish; pleura wholly black-haired. Length, 8·5 to 10 mm.

♂. Head cinereous to white pollinose. Front about one-third as wide as greatest width of either eye; frontal vitta black, usually considerably narrower than either parafrontal, rarely almost as wide anteriorly; about fourteen pairs of frontals, the lower three pairs situated below the base of the antennae, the upper two reclinate, those toward the upper part of the front weaker and shorter; hair rather abundant; ocellars fine but long. Outer verticals absent; occipital cilia in a single row, fine; pile white. Cheeks one-twelfth to one-fourteenth as wide as eye-height, covered with short pile except along the orbits. Parafacials narrow, widening above; vibrissae situated level with the oral margin, the ridges on the lowest fourth with many bristly hairs or weak bristles. Palpi reddish. Antennae black, the third segment rather narrow, obtusely rounded apically, about three times as long as the second; arista slender, thickened on the basal third. Eyes tawny pilose. Thorax black, the sides of the mesonotum more or less brownish-

red; pollen fairly thick; varying from cinereous to cinereous-brown, the vittae narrow but distinct; in some specimens the mesonotum is rather shining from dorsal view. Chaetotaxy complete, four pairs of marginal scutellars, the apical pair cruciate; sternopleurals 1–1; pleura wholly black-haired. Legs black, the tibiae sometimes more or less brownish-red. Middle tibiae with a single anterodorsal bristle; posterior tibiae long ciliate; pulvilli rather long. Wings cinereous-hyaline, more or less tinged with brown in front; epaulet black. Squamae greyish-white. Halteres reddish. Abdomen reddish and black, with white or cinereous pollen. First segment reddish, the median third black; second reddish with a broad median vitta which expands posteriorly and sometimes a more or less distinct posterior fascia, black; third segment reddish with a broad median vitta and the apical third or more black; fourth segment variable, usually reddish with a very broad, incomplete, black median vitta or spot. The pollen forms interrupted bands on the basal two-thirds or less of the second and third segments; on the fourth segment it is usually tinged with brownish-yellow and covers almost the whole segment, but when viewed with the naked eye it appears to form a very broadly interrupted band. First and second segments each with a pair of marginals, the third with a row; fourth segment with erect, bristly hair; the hair on the middle of the two preceding segments rather erect and longer than on the sides.

♀. Front three-eighths as wide as either eye; two pairs of frontals; frontal pollen strongly tinged with yellowish. Abdomen usually darker, the segments with more distinct black apical fasciae.

Type ♂ and allotype ♀, Brisbane, Queensland (Dr. A. J. Turner), in the collection of the School of Public Health and Tropical Medicine, University of Sydney; paratypes, 6 ♂, 2 ♀, Brisbane (Dr. Turner); ♂, Townsville, Queensland (Dr. Welch).

ZENILLIA DODDI, n. sp.

Black, the sides of the second abdominal segment more or less reddish; pollen cinereous; sternopleurals 1–1; middle tibiae with two anterodorsal bristles. Length, 11 to 12 mm.

♂. Head white pollinose, the front yellowish. Front about four-fifths as wide as greatest width of either eye; frontal vitta blackish, a little more than half as wide as either parafrontal; nine pairs of frontals, the upper two reclinate, the lowest three pairs situated below the base of the antennae, the rows strongly diverging; ocellars strong. Outer verticals absent; occipital cilia in a single row; pile white. Cheeks almost one-third as wide as eye-height, with black hair, that on the upper part fine. Parafacials as wide as the third antennal segment, slightly narrowing below. Vibrissae situated distinctly above the oral margin, the ridges with four or five bristly hairs immediately above them. Palpi reddish. Antennae black, the second segment and base of the third more or less reddish; third segment little more than twice as long as the second, moderately broad, obtuse apically, the upper corner sharply rounded; arista missing. Eyes cinereous-white pilose. Thorax cinereous-pollinose, the four dark vittae narrow but distinct. Chaetotaxy normal; scutellum with four pairs of marginals, the apical pair strong and cruciate; sternopleurals 1–1. Hair black. Scutellum brownish-yellow in ground colour. Legs black; middle tibiae with two strong anterodorsal bristles; posterior tibiae not ciliate; pulvilli elongate. Wings cinereous-hyaline, the base tinged with yellow. Squamae cinereous-white; halteres yellow. Abdomen black, the sides of the second segment reddish on the basal three-fifths; slightly more than the

basal half of the second to fourth segments, cinereous pollinose, the pale bands appearing narrowly interrupted from most views. First and second segments with pair of marginals, the third and fourth each with a row; fourth segment with a row of marginals and sub-erect bristly hair.

Type ♂ and ♂ paratype, Herberton, Queensland, 12.1910. The type is in the Deutsches Entomologisches Museum, the paratype in the American Museum of Natural History.

ZENILLIA PICTA, n. sp.

Thorax yellow-pollinose, with a transverse black spot immediately behind the suture; wings brown in front except apically. Length, 7 to 7·5 mm.

♂. Face and lower half of the occiput whitish-pollinose, more or less tinged with yellow; cheeks, front, and upper half of the occiput pale golden-yellow. Front half as wide as greatest width of either eye, the frontal vitta blackish, narrower than either parafrontal except above; seven or eight pairs of frontals, the lowest four pairs situated below the base of the antennae, the upper two strong and reclinate; ocellars well developed. The black occipital cilia do not extend to the cheeks; pile white on the occiput and posterior half or more of the cheeks, the latter two-sevenths as wide as the eye-height. Parafacials narrower than the third antennal segment; vibrissae situated slightly above the anterior oral margin, the ridges with several bristly hairs above them. Palpi reddish. Antennae black, the second segment more or less reddish, short; third segment very long, more than five times as long as the second, of moderate width; arista thickened on the basal third. Eyes yellow pilose. Thorax golden-yellow, the deep black vittae in front of the suture paired and strong, not quite reaching the broad incomplete, transverse post-sutural band; posterior calli shining brown. Chaetotaxy complete, four pairs of marginal scutellars, the apical pair weak and cruciate; sternopleurals 2–1. Scutellum black, the apical third reddish in ground colour and densely yellow-pollinose. The pleural pollen becomes paler below. Hair wholly black. Legs black or brown; anterior tibiae with two posterior bristles, the middle pair with a single anterodorsal; posterior tibiae sparsely ciliate; pulvilli moderately long. Wings cinereous hyaline, the costal border, tapering to the end of the subcostal cell, brown, the base of the wings paler. Squamae whitish-yellow; halteres brownish-yellow. Abdomen black or brown, with narrow, yellowish or cinereous pollinose fasciae on the second to fifth segments, that on the second segment very narrow and obsolete on the median third, all the fasciae greatly widening on the venter; first segment with a pair of weak, the second with strong marginals, the third and fourth each with a row; hair sub-erect to erect on the median portions of the segments, entirely erect on the fourth.

♀. Front a little more than three-fifths as wide as either eye; two pairs of orbitals; middle tibiae with two anterodorsal bristles; pollinose band on second abdominal segment entire. In the female the black fascia on the mesonotum occupies about half the postsutural area, whereas, in the male, it occupies distinctly more than half.

Type ♂, Herberton, Queensland, 2.1911 (F. P. Dodd), in Deutsches Entomologishes Museum; allotype ♀, and two ♀ paratypes, Brisbane, Queensland (Dr. A. J. Turner) in the collection of the School of Public Health and Tropical Medicine, University of Sydney, a paratype in the American Museum of Natural History.

ZENILLIA NITIDICAUDA, n. sp.

Black, including the palpi and scutellum, the pollen whitish cinereous. Length, 9·5 to 11 mm.

♂. Parafacials reddish in ground colour; head white-pollinose. Front hardly two-thirds as wide as greatest width of eye, widening on the anterior half; frontal vitta black, about as wide as either parafrontal; about twelve pairs of rather fine frontals, the lower two pairs situated below the base of the antennae, the upper three or four reclinate; ocellars long. Occipital cilia in a single row; pile white; cheeks three-tenths as wide as the eye-height, with black hair on lower fourth. Vibrissae situated level with the oral margin; five or six bristles on the ridges immediately above them. Parafacials about as wide as the antennae, slightly narrowing below. Palpi black. Antennae black, the second segment more or less reddish, almost half as long as the third; third segment elongate, widest on the apical half, the apex very obtusely rounded; arista thickened on basal fifth. Eyes white pilose. Thorax thickly cinereous-pollinose, the black vittae narrow and poorly developed. Chaetotaxy complete; four pairs of marginal scutellars, the apical pair cruciate; sternopleurals 2–1. Hair wholly black. Scutellum entirely black in ground colour. Legs black; middle tibiae with two strong anterodorsal bristles; posterior tibiae with a row of anterodorsals, not ciliate; anterior tibiae with two posterior bristles. All the pulvilli elongate, yellowish. Wings cinereous hyaline; third vein with three or four bristles basally. Squamae whitish. Halteres with brown knob. Abdomen black, the second and third segments cinereous-pollinose on the basal two-thirds, less thickly so in the middle, the pollen appearing slightly tessellate in some views. First and second segments each with a pair of marginals, the third and fourth each with a row, the fourth with erect bristly hair.

Type ♂, Cairns, Queensland; paratypes, 2 ♂, Mt. Molloy, Queensland (F. H. Taylor), ♂, Palm Island, Queensland (D. H. K. Lee), in the collection of the School of Public Health and Tropical Medicine, University of Sydney. Paratype in American Museum of Natural History.

ZENILLIA TRISTIS, n. sp.

Black, with cinereous pollen; sternopleurals 2–1; facial ridges with bristly hairs on the lowest third. Length, 8 to 9 mm.

♀. Head white-pollinose, the front somewhat more cinereous. Front almost four-fifths as wide as greatest width of either eye; frontal vitta blackish, almost as wide as either parafrontal; six or seven pairs of frontal bristles, the lowest two situated below the base of the antennae, the upper two pairs reclinate; hair very sparse; ocellars long and strong. Outer verticals weak; occipital cilia in a single row; pile white. Cheeks almost one-fourth as wide as the eye-height, black-haired. Parafacials narrower than the third antennal segment, narrowing below; vibrissae situated level with the oral margin, the ridges with short, bristly hairs on about the lowest third. Palpi reddish. Antennae black; third segment about two and one-half times as long as the second, the apex obtuse; arista slender, tapering on the basal half. Thorax black, cinereous-pollinose, the black vittae poorly developed. Chaetotaxy complete; four pairs of marginal scutellars, the apical pair fairly strong and cruciate; sternopleurals 2–1. Scutellum wholly black in ground colour, densely whitish-pollinose except on the broad base. Hair black. Legs black; middle tibiae with three anterodorsal bristles, the posterior pair not ciliate. Wings cinereous-hyaline. Squamae cinereous-white; halteres reddish. Abdomen black, with cinereous-white pollen which forms bands across the anterior two-fifths of the second to fourth segments, the bands, in some lights, interrupted in the middle. First and second segments each with a pair of marginals, the third and fourth each with a row; fourth segment with an irregular row of discals and erect, bristly hairs.

Type ♀, Cairns, Queensland, 1917, in Deutsches Entomologishes Institute; paratype ♀, Mt. Molloy, Queensland (F. H. Taylor), in the collection of the School of Public Health and Tropical Medicine, University of Sydney.

ZENILLIA TAYLORI, n. sp.

A small species resembling *cosmophilae* but with four sternopleural bristles which at once distinguish it from any Australian species except *quadrisetosa*. Length, 7 to 7·25 mm.

♂. Head white-pollinose, the front more cinereous. Front more than half as wide as greatest width of either eye, the black frontal vitta little more than half as wide as either parafrontal; eight or nine pairs of frontal bristles, the lowest three pairs situated below the base of the antennae, the upper pair reclinate, hair fairly abundant; ocellars and outer verticals absent. Occipital cilia in a single row; pile yellowish-white; cheeks almost one-fourth as wide as eye-height, with short black hair except above. Parafacials less than half as wide as the third antennal segment; vibrissae situated slightly above the oral margin, the ridges with four or five bristles immediately above them. Palpi reddish. Antennae black, the second segment short, the third a little more than three times as long, moderately broad and obtuse at the apex; arista thickened on the basal third. Eyes with cinereous pile. Thorax black, with cinereous-white pollen, the mesonotum only thinly pollinose and the vittae indistinct. Chaetotaxy complete; scutellum with three or four pairs of strong marginals, the second pair absent or present, the apical pair parallel and strong, the true apicals absent; sternopleurals 2–2. Scutellum rather shining brownish-red, the base black. Legs black; anterior tibiae with two posterior bristles; the middle pair with two anterodorsals, the posterior tibiae long ciliate; pulvilli of medium length, pale yellowish. Wings cinereous-hyaline; third vein with three or four basal bristles. Squamae whitish; halteres reddish. Abdomen black, with cinereous pollen, the sides of the second and third segments more or less reddish on the basal half. The pollen leaves somewhat more than the apical fourth of the second and third segments bare, and is brown along the middle line, the fourth segment with almost the apical half bare. First and second segments without median marginals, the third and fourth each with a row, the fourth with a row of discals. Hair erect on the fourth segment.

Type ♂ and one paratype, Innisfail, Queensland (F. H. Taylor). Type in the collection of the School of Public Health and Tropical Medicine, University of Sydney.

It is possible that a new genus should be erected for this species, but until both sexes are known I leave it provisionally in *Zenillia*. The species following is very much like *taylori* but ocellars are present, the first two abdominal segments bear marginals and the thorax is thickly cinereous-pollinose. I do not think that these forms represent the two sexes of the same species, but such may be the case. Until specimens have been taken together they may be considered as distinct species.

ZENILLIA QUADRISETOSA, n. sp.

At once distinguished from *taylori* by the presence of strong ocellar bristles, etc. Length, 7·25 mm.

♀. Head white-pollinose, the frontal pollen with yellowish tinge. Front a little more than three-fifths as wide as greatest width of either eye, gently widening anteriorly; eight pairs of frontals, the lowest three pairs below the base of the

antennae, the upper two reclinate; hair sparse; ocellars long and strong. Outer verticals long; occipital cilia in a single row; pile yellowish-tinged; cheeks about one-seventh as wide as eye-height, haired except above. Parafacials less than half as wide as the third antennal segment, widened above. Vibrissae situated almost level with the oral margin, the ridges with four or five bristles immediately above them. Palpi reddish, slightly elongated. Antennae black, the third segment more than three times as long as the second, moderately broad, its sides parallel, the apex obtuse; arista thickened on basal third. Eyes with pale-yellowish pile. Thorax black, thickly cinereous-pollinose, the black vittae weakly developed. Chaetotaxy complete; scutellum with three pairs of marginals and a very weak, upturned apical pair, the apical border broadly reddish-yellow in ground colour; sternopleurals 2–1. Legs black; anterior tibiae with two posterior bristles; middle tibiae with a single anterodorsal bristle, the posterior pair sparsely long ciliate; pulvilli short. Wings cinereous-hyaline, the base a little yellowish. Squamae whitish; halteres reddish. Abdomen black, the second segment broadly reddish on the sides of the anterior two-thirds; second to fourth segments cinereous-pollinose, the apical third of each segment and a sub-obsolete median vitta, shining or dark. First and second segments each with a pair of marginals, the third and fourth with a row, the fourth with a row of discals and erect hair.

Type ♀, Palm Island, Queensland (Mrs. F. H. Taylor), in the collection of the School of Public Health and Tropical Medicine, University of Sydney; paratype ♀, Kuranda, Queensland, in American Museum of Natural History.

ZENILLIA SAPIENS, n. sp.

Black, with cinereous pollen; sternopleurals 2–1; middle tibiae with two anterodorsal bristles; pulvilli elongate. Length, 12·5 mm.

♂. Head whitish-pollinose, the front cinereous-yellow. Front four-sevenths as wide as greatest width of either eye; frontal vitta blackish, narrower than either parafrontal; ten or eleven pairs of frontals, the lowest three pairs situated below the base of the antennae in strongly diverging rows, the upper two pairs reclinate; ocellars long and strong, hair on parafrontals fine and long. Outer verticals not developed; a row of black setae behind the occipital cilia; pile white. Cheeks more than one-fourth as wide as eye-height. Vibrissae situated slightly above the oral margin, the ridges with bristly hairs on almost the lower half; parafacials almost as wide as the third antennal segment, gently narrowing below. Palpi reddish. Antennae black, the third segment two and a half times longer than the second, moderately wide, the apex oblique above (perhaps an abnormal condition); arista missing. Thorax cinereous-pollinose, with yellowish tinge dorsally, the black vittae narrow. Chaetotaxy complete. Four pairs of marginal scutellars, the apical pair strong and cruciate; sternopleurals 2–1; hair black. Scutellum reddish in ground colour, the base broadly blackish. Legs black; posterior tibiae closely ciliate. Wings cinereous-hyaline, broadly tinged with brown in front; epaulet black. Squamae white; halteres reddish-yellow. Abdomen black, with cinereous pollen, the sides of the second segment more or less reddish on the basal half. The pollen forms fasciae on the second to fourth segments, that on the second occupying a little less than the basal half, those on the third and fourth slightly more than the basal half, all the fasciae almost interrupted in the middle by a slender black line. First and second segments each with a pair of quite short marginals, the third and fourth each with a row, the fourth with a row of stouter discals and erect bristly hair.

Type ♂, Philippine Islands (Osten-Sacken Collection), in the Deutsches Entomologisches Museum.

Additional Species of Zenillia *described from Australia.*

Inasmuch as the descriptions of the following species are incomplete and will agree with several forms occurring in the region, it is impossible to associate specimens with them and only an examination and elucidation of the types will render the names available. It is probable that some of the species described as new in the foregoing pages will prove to be synonyms. It cannot be assumed, however, that all, or any, of the species listed below actually belong to *Zenillia*, since the generic characters were very broadly interpreted by early authors.

Tachina (*Carcelia*) *coras* Walker, *List Dipt. Brit. Mus.*, iv, 1849, 785 (W. Austr.).

Exorista dispar Macquart, *Dipt. Exot.*, Suppl. iv, 1850, 159 (186) (Austr.).

Exorista diversicolor Macquart, *Dipt. Exot.*, Suppl. ii, 1847, 83 (Tas.).

Exorista flaviceps Macquart, *Dipt. Exot.*, Suppl. ii, 1847, 83 (Tas.).

Exorista marginata Macquart, *Dipt. Exot.*, Suppl. iv, 1850, 161 (Tas.).

Exorista melas Bigot, *Ann. Soc. Ent. France*, 1888, 256 (Tas.).

Tachina (*Phryno*?) *remota* Walker, *Dipt. Saunders.*, 1852, 280 (N.S.W.).—This is apparently a *Phorocera*, although *Z. tristis* n. sp. has the facial ridges with hairs half-way up. Perhaps the two names apply to the same species.

Exorista rufomaculata Macquart, *Dipt. Exot.*, Suppl. iv, 1850, 160 (Tas.).

Exorista translucens Macquart, *Dipt. Exot.*, Suppl. iv, 1850, 162 (Tas.).

A KEY TO THE MARINE ALGAE OF NEW SOUTH WALES.

Part 1. CHLOROPHYCEAE.

By VALERIE MAY, B.Sc., formerly Science Research Scholar in Botany, the University of Sydney.

[Read 27th July, 1938.]

Introduction.

The Marine Algae include very diverse forms, varying from unicellular, motile organisms to highly differentiated, attached thalli. Of these, this paper is concerned with attached, littoral marine forms only; these may be branched and bear leaf-like appendages.*

The geographic disposition of algae is affected greatly by light, and the influence of temperature is illustrated by the alterations in the flora due to warm or cool currents. The vegetation of any one locality is influenced by factors which affect the efficiency of the holdfast, as, for instance, the type of substrate (permanent—rock, or unstable—sand or mud), steepness of slope, degree of smoothness, and the extent of exposure to storms. Where the substrate is of sand or mud a further complication is introduced, in that 'silting up' occurs. Proximity to land influences the habitat through aeration and drainage. Some marine plants are never exposed between tides, while others are rarely, if ever, covered, receiving merely sea spray at high tides. The plants which occur above low-tide level, as compared with the completely submerged types, are subject to very much greater variation in such factors as temperature, salinity (which may be increased by evaporation from pools, or decreased by dilution with fresh water), aeration, hydrogen-ion concentration and light. The plants of the inter-tidal zone may be classified into those which are completely exposed, and those which occur in rock pools. The exposed forms are liable to suffer from excessive loss of water. With increasing depth of water the light intensity decreases logarithmically. This progressive change in habitat results in a vertical zoning of the plants. That the controlling factor in this zonation is light, not depth, is shown by the occurrence of a similar sequence of algal forms inwards from the mouth of a cave. Plants may affect each other by competition or indirectly, as, for instance, by an abundant crop of epiphytes causing too great a strain on the holdfast of the host-plant. Occasionally parasitism occurs. With plants possessed of varied degrees of adaptation to each of these interacting factors, there is possible a high degree of complexity in the structure of the community. To this must be added that in many cases the relative frequency of a plant varies seasonally, so that ecological work, to be by any means complete, should cover at least the year.

Variation in form is common among the algae; this may be due to seasonal changes (e.g. *Pylaiella littoralis*) or to differences of habitat. Variation due to habitat may affect intensity of colour (especially among the Red seaweeds), body

* For simplicity, in the key, these are referred to as 'leaves'.

shape (*Hormosira Banksii*), plant size* (*Enteromorpha intestinalis*), cell size* (*Ectocarpus confervoides*) and even the presence or absence of vesicles (*Blossevillea retroflexa*). It would seem necessary to examine a plant throughout at least one year and to collect it from different habitats in order to determine its range of variation.

Since autotrophic organisms, in the sea as on the land, are the source of energy for all others, it is important that something should be known of 'the pastures of the sea'. Formerly the planktonic section was considered more important in this connection. Now, however, the attached plants and accumulated detritus are recognized by many as at least comparable in importance. More work is needed to establish connected food chains of the sea. As Tilden (1935) says, 'it is time that the primary links of the food chain received due recognition'. It was an interest in animal-plant relationships which led to the preparation of this paper, 'for, after all, no satisfactory progress is possible until one can be sure of the species of the animal that devours and of the plant devoured' (Tilden, 1935). The food value of marine algae is now slightly recognized, and Occidentals are following the example of many Pacific Island dwellers and Orientals in including this in their diet. As yet the Japanese lead the way in the economic culture of seaweeds. Medicinally 'Irish Moss' has been used for many years. There is no seaweed known to be poisonous.

Further uses to which various algae have been put include the feeding of sheep and cattle, agar-agar manufacture, soil fertilizing, paper manufacture, and sodium, potassium, iodine and bromine extraction.

Systematic work on the Australian seaweeds was begun early in the nineteenth century. Lucas (1936) gives an outline of the progress of phycology in Australia. Harvey (1863) and Sonder (1880) each presented a list of Australian seaweeds and localities from which they had been recorded. In 1909–1912 Lucas published a list of the seaweeds then recorded from Australia, together with the letters E, W, N and S to show the distribution. There were 20 species of green seaweeds from the east coast (E). Since that time Lucas has published odd notes adding to the knowledge of distribution, but no further comprehensive list has appeared. The position then is that there exists no complete account of the algae found on the coast of New South Wales. The only keys available at all pertaining to Australian seaweeds are those of Lucas (1936) and Bastow (1898, 1899). The genera have been altered considerably since the publication of Bastow's work. Accordingly an essential prelude to algology in New South Wales is a list of the species recorded from the State and a simple mode of distinguishing them. The present series aims at supplying this information and also at bringing the terminology and classification as up-to-date as possible. In this paper the green seaweeds only are presented; it is hoped to publish further contributions in other groups later.

* It appears to the writer that the customary method of using cell and/or plant size for specific determinations is unsatisfactory. In the literature there abound conflicting reports of the size limits of a species. As an example, Setchell and Gardner (1925) and Newton (1931) report differently as to the size of the plant of *Ectocarpus confervoides* (Roth.) Le Jol.; their reports differ also as to the limits to size in vegetative cells and reproductive units in *E. terminalis* Kuetz. The writer took a series of measurements of the cell lengths in branches of a single plant of *E. confervoides* (Roth.) Le Jol. The mean was 0·0651 mm., and σ was 0·0208 mm. It follows that in this instance there must be a difference of at least 37% in cell size before the length of the cells becomes significant as a means for separating species.

In order to learn what species had been recorded from New South Wales, the algal herbaria at the National Herbarium, Sydney, the Council for Scientific and Industrial Research, Canberra, and the University of Sydney, were examined. The localities given for those plants which were definitely named were noted and are quoted in the body of this paper. Professor Lucas had been an Honorary Custodian of the algae at the National Herbarium for many years, and the collections at the C.S. and I.R., Canberra, and at Sydney University, were named by him, so it would seem that all the plants examined may be considered as named or accepted by him. Besides the localities mentioned on herbarium material, additional localities were sought in all available literature.

The occurrence of New South Wales plants at Lord Howe Island or Norfolk Island has been noted for comparison; similarly any occurrence in the adjoining States of Victoria and Queensland was included when herbarium material recorded those localities, but all literature was not consulted, because it is impossible to complete the series without consulting the Queensland and Victorian herbaria also.

There are now 34 species of green seaweeds recorded from New South Wales (cf. 20 'E' in 1912). Further study will add, almost certainly, to this number.

In addition to the making of a list of those species recorded from the coast of New South Wales, and of their distribution, as far as known, an attempt has been made to construct a natural key. Where any large group which is known to include marine forms is not represented from the territory under discussion a note has been made regarding it in the key.

Under each species name are listed, at the end of the paper, those synonyms attributed to it by various workers. In each case reference is given to an authority for the acceptance of the synonymy. Following this is an alphabetical list of the synonyms which allows quick reference to the key.

The abbreviations used below as sub-headings under localities are as follows:
C.S. & I.R.: Lucas Collection, Council for Scientific and Industrial Research, Canberra.
D.T.: De Toni, G. B. (1889).
Harv. Aus.: Harvey, W. H. (1858-63).
Herb. Notes: Notes or lists of collections found at the National Herbarium, Sydney.
Laing: Laing, R. M. (1900).
Muell.: Sonder, W. (1880).
Nat. Herb.: The algal section, National Herbarium, Sydney.
Okamura: Okamura, K. (1904).
Sonder: Sonder, W. (1871).
University: The algal herbarium, University of Sydney.

I wish to express thanks to Assistant-Professor J. McLuckie, Botany School, University of Sydney, to the authorities of the National Herbarium, Sydney, and of the Division of Plant Industry, C.S. & I.R., Canberra; without the facilities made available by them this work would not have been possible. I have pleasure also in thanking Mr. R. H. Anderson, Government Botanist and Curator, National Herbarium, and Professor Eric Ashby for their help and criticism during the preparation of this paper.

The classification used in the present key is as follows:

CHLOROPHYCEAE.

Protococcales.
Ulotrichales.
Schizogoniales.
Ulvales: Ulvaceae (1. *Enteromorpha*; 2. *Ulva*).

Siphonales: Protosiphonaceae; Bryopsidaceae (3. *Bryopsis*); Derbesiaceae; Vaucheriaceae (4. *Vaucheria*); Codiaceae (5. *Codium*); Caulerpaceae (6. *Caulerpa*).

Siphonocladiales: Dasycladiaceae (7. *Acetabularia*); Valoniaceae (8. *Microdictyon*); Cladophoraceae (9. *Chaetomorpha*; 10. *Rhizoclonium*; 11. *Cladophora*).

Chlorophyceae Kuetz.

i. Plant uni- or multi-cellular; normal cells uninucleate, although attachment rhizoids may be coenocytic. This includes Protococcales (Meneghini) Oltmanns: Cells solitary or in non-filamentous colonies; Ulotrichales Blackman and Tansley: Thallus filamentous and chromatophores parietal; Schizogoniales West: Thallus simple, filamentous and chromatophores axile.
Thallus membranaceous; chromatophore parietal; pyrenoid(s) present; frond of one or two layers of cells; cylindrical form sometimes assumed ..... Order Ulvales Blackman and Tansley.

ii. Plant uni- or multi-cellular, coenocytic.
Plant a single coenocyte which may produce a complex individual; transverse walls occur only in connection with reproduction, or as secondary septa-'plugs'; chloroplasts lens- or disc-shaped and numerous; cytoplasm lines the wall and there is a continuous, sap-containing cell cavity .. Order Siphonales (Grev.) Oltmanns.
Plant a series of coenocytes; chromatophores usually numerous, small, disc-shaped, each with one pyrenoid, or large, single, parietal, reticulate, with many pyrenoids ..... Order Siphonocladiales (Blackman and Tansley) Oltmanns.

Order Ulvales Blackman and Tansley.

Only family ..... Ulvaceae Grev.
Frond tubular even at maturity ..... 1. *Enteromorpha* Link.
In mature frond there are two continuous layers of cells united wholly or in part; frond broad, expanded ..... 2. *Ulva* Linn.

Order Siphonales (Grev.) Oltmanns.

New South Wales possesses no members of the Protosiphonaceae Blackman and Tansley; this family is unique for this order in that the thallus is not filamentous.

Filaments free.
Fronds pinnately branched ..... Bryopsidaceae (Bory.) D.T.
Chromatophores numerous, disc-shaped and each with one pyrenoid. Only genus recorded from N.S.W. ..... 3. *Bryopsis* Lamour.
Fronds irregularly or dichotomously branched. This includes Derbesiaceae (Thur.) Kjellm. Anisogamous; zoospores single, with many cilia .... Vaucheriaceae Dumort.
Filaments continuous, without constriction. Only genus recorded from N.S.W. .... 4. *Vaucheria* DC.

Thallus complex, filaments being interwoven, or strengthened by trabeculae.
Thallus composed of intertwined, branching filaments; peripheral branchlets forming a palisade or pavement-like, external layer ..... Codiaceae (Trev.) Zan.
Thallus spongy, not jointed nor calcified. Only genus recorded from N.S.W. .... 5. *Codium* Stackh.
Thallus consists of a creeping, rhizome-like axis—absent in *C. ambigua* Okamura—bearing branched rhizoids or holdfasts on its underside and foliar shoots from the upper; trabeculae, which traverse the lumen of the coenocyte from wall to wall, brace the system internally ..... Caulerpaceae Reichenbach.
Only genus ..... 6. *Caulerpa* Lamour.

Order Siphonocladiales (Blackman and Tansley) Oltmanns.

Thallus consists of a much elongated, cylindrical, axial segment, bearing at its apical portion numerous, acropetal whorls of branches ..... Dasycladiaceae (Endl.) Cramer.
Sporophyte erect, calcareous and terminated above by a disc, or series of superimposed discs, of laterally-coherent branch coenocytes arranged in a whorl; these bear projections forming rings—'coronae'—on one or both faces near the apex.
Only genus recorded from N.S.W. ..... 7. *Acetabularia* Lamour.

Frond of simple or branching, monosiphonous filaments, free or more or less united laterally; all axes of indefinite growth.
Segregative division occurs, i.e., membranes are formed around central or peripheral accumulations of protoplasm and chloroplasts and thus more or less numerous, small cells are formed ..... Valoniaceae Oltmanns.

Branched filaments anastomose, forming a network in one plane, the whole resembling the softened skeleton of a dicotyledonous leaf; cells uniform and cylindrical; lobed chromatophores usually arranged to form a network. Only genus recorded from N.S.W. ..... 8. *Microdictyon* Decne.*

Cell division not segregative; cell network not formed; walls usually thick and clearly stratified ..... Cladophoraceae (Hass.) D.T.

Filaments simple, or very nearly so.

Filaments usually stiff or rigid; rhizoidal branchlets absent; slight constrictions usually occur between the cells ..... 9. *Chaetomorpha* Kuetz.

Filaments flaccid, unattached and prostrate; rhizoidal branchlets occur; filaments not constricted as in *Chaetomorpha* ..... 10. *Rhizoclonium* Kuetz.

Filaments branched, but not held together by special branchlets ..... 11. *Cladophora* Kuetz.

Genus 1. Enteromorpha Link.

Cells not arranged in longitudinal series except perhaps in the youngest parts.

Thallus simple or with few branches; usually inflated and constricted and often of a large size ..... 1. *E. intestinalis* (Linn.) Link.

Locality.—C.S. & I.R.: Botany Bay, Bondi, Port Jackson. Sonder: (also Queensland).

Thallus produces more or less numerous branches.

Branches attenuate at the base and apex ..... 2. *E. lingulata* J. Ag.

Locality.—Nat. Herb.: Bondi (also Victoria).

Branches attenuate at the base only ..... 3. *E. compressa* (Linn.) Grev.

Locality.—Nat. Herb.: Cook's River, Coogee (not labelled), (also Queensland). C.S. & I.R.: Port Jackson. Harv. Aus.: 'All parts of coast and estuaries.'

Cells arranged in a longitudinal series in the greater part of the frond; thallus regularly and proliferously branched; branches similar to the main filaments ..... 4. *E. prolifera* (Muell.) J. Ag.

Locality.—Nat. Herb.: Botany Bay, Port Jackson.

Genus 2. Ulva Linn.

Frond lanceolate with a tubular stipe ..... 5. *U. Linza* Linn.†

Locality.—Nat. Herb.: Plant as *Enteromorpha Linza* (Linn.) J. Ag., Port Jackson.

Frond variously shaped; stipe, when present, solid; thallus often deeply split.

Frond of long, twisted ribbons, the margins of which are abundantly and closely undulate; the two layers of cells easily separable in the upper parts ..... 6. *U. laetivirens* Aresch.

Locality.—Nat. Herb.: Port Jackson. C.S. & I.R.: (also Victoria).

Frond of variable outline, ovate to lanceolate, more or less folded; margin usually quite entire; shortly stipitate or nearly sessile ..... 7. *U. lactuca* Linn.

Locality.—Nat. Herb.: Botany Bay (also Victoria and Lord Howe Is.). Sonder: Richmond River. Harv. Aus.: 'Australian coasts.' Okamura: Plant as *U. rigida* Ag., Sydney.

Genus 3. Bryopsis Lamour.

Ramuli distinctly spreading, arising, usually alternately, at rather long intervals except at the tips of the branches; they are very long, constricted at the base, but do not taper to the blunt apex ..... 8. *B. baculifera* J. Ag.

Locality.—Lucas (1913): Parramatta River (also Victoria).

Ultimate ramuli form plumes with distichous, slender, pinnules, gradually narrowed above and to the base ..... 9. *B. plumosa* (Huds.) Ag.

Locality.—Nat. Herb.: Parramatta River (also Victoria and Queensland). C.S. & I.R.: (also Lord Howe Island). Harv. Aus.: 'Coasts of Australia.'

Genus 4. Vaucheria DC.

Male and female reproductive organs occur on separate filaments; antheridia egg-shaped or ellipsoidal and sessile; oogonia spherical or slightly elongated and with a terminal ostiole; sperm liberation by a definite, apical aperture .... 10. *V. dichotoma* (Linn.) Ag.

Locality.—Nat. Herb.: Stanwell Park (tidal).

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* Proof of segregative division is not completed as yet; the classification of this genus, therefore, may later be changed.

† Authorities differ as to whether this plant should be called *Ulva Linza* Linn. or *Enteromorpha Linza* (Linn.) J. Ag., as it is intermediate between the two genera.

Genus 5. Codium Stackh.

Thallus prostrate and unbranched.

Thallus forms a broad, green, sponge-like, felted, encrusting layer; utricle hairs present ..... 11. *C. adhaerens* (Cabr.) Ag.

Locality.—Harv. Aus.: Port Jackson. Herb. Notes: (also Queensland).

Thallus cushion-shaped and lobed.

Thallus dark green ..... 12. *C. Lucasii* Setchell.

Locality.—C.S. & I.R.: Eden, Maroubra, Bondi, Long Reef (also Victoria and Lord Howe Island). Lucas (1935): Newcastle.

Thallus light green ..... 13. *C. spongiosum* Harv.

Locality.—Nat. Herb.: Port Jackson, Lake Macquarie (also Queensland). C.S. & I.R.: (also Lord Howe Island).

Thallus erect; fronds dichotomous.

Fronds flattened, especially beneath forkings.

Utricles 0·4 mm. or more in diameter, never mucronate ..... 14. *C. decorticatum* (Woodw.) Howe.

Locality.—Nat. Herb.: Botany Bay. C.S. & I.R.: Port Jackson (also Victoria). Lucas (1936): (also Lord Howe Island). Herb. Notes: (also Queensland).

Utricles up to 0·4 mm. in diameter and bearing short hairs near their outer ends ..... 14*a*. *C. cuneatum* S. & G.

Locality.—Lucas (1935): Botany Bay, Port Jackson. C.S. & I.R.: (also Queensland and Lord Howe Island).

Fronds cylindrical, terete.

Utricles flattened or rounded, vesiculose, the membrane not much thickened ..... 15. *C. Muelleri* Kuetz.*

Locality.—Nat. Herb.: Eden, Jervis Bay (cast up), Maroubra, Botany Bay (also Victoria and Queensland). C.S. & I.R.: Port Jackson, Collaroy, Lake Macquarie. Sonder: Ballina, Richmond River. Lucas (1936): 'Round Australia and Tasmania.' Laing (also Norfolk Island). Herb. Notes: Clarence River.

Utricles end in a sharp or blunt point (mucro), most obvious where there is young growth ..... 16. *C. fragile* (Suring.) Heriot.

Locality.—Nat. Herb.: Eden, Long Bay, Port Jackson (also Victoria); plant as *C. mucronatum* J. Ag., Brisbane Waters; Port Macquarie, Bermagui River. C.S. & I.R.: Botany Bay, Bondi, Collaroy. Herb. Notes: Lake Macquarie, Manning River.

Genus 6. Caulerpa Lamour.

Stolons covered with scales; fronds cylindrical; branching distichous, sub-opposite or alternate; ramenta simple or bifid, mucronate ..... This is the sub-genus *Arancarioideae* J. Ag.

Frond feather-like in shape; ramenta of trunk and branches shortly subulate with bi-mucronate tips, arranged in pairs, which are sometimes united and so appear as a single, forked structure ..... 17. *C. hypnoides* (R. Br.) Ag.

Locality.—Nat. Herb.: Eden, Sydney district (also Victoria). Lucas (1936): 'Anywhere on Australian and Tasmanian coasts.'

Some workers divide this species further as:

Ramenta pairs united for some distance above the base ..... *C. Muelleri* Sond.

Ramenta pairs united only at base; colour darker, growth more robust, ramenta more erect, scales of stolons less densely set and less finely divided than in the above species ..... *C. hypnoides* (R. Br.) Ag.

Stolons bare.

Fronds flat, deeply dentate, pinnulate or pinnate, rarely cylindrical and then surrounded by filiform pinnules reaching up to four times the diameter of the central axis ..... This is the sub-genus *Filicoideae* J. Ag.

Frond large, plane, lanceolate-linear, simple or branched, pinnate or lobed; pinnules of lobes usually alternate, sometimes sub-opposite; tips attenuated and entire or toothed and rounded ..... 18. *C. scalpelliformis* (R. Br.) Ag.

Locality.—Nat. Herb.: Jervis Bay (cast up) (also Victoria).

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* Lucas (1936) calls this 'the Indo-Pacific representative of the more specially Atlantic species, *C. tomentosum* (Huds.) Stackh.'. Probably Sonder (1880) is referring to this species when recording *C. tomentosum* Ag. as occurring on the 'Coasts of Australia and Tasmania'.

Fronds not deeply dentate, pinnulate nor pinnate.

Fronds bear distichous, alternate or multiseriate ramuli which are ovoid in shape, cylindrical or linear and sessile or pedicellate; fronds simple or branched, articulate or not ..... This is the sub-genus *Sedoideae* J. Ag.

Central axis not, or slightly, articulate; ramuli sessile, spherical or obovate, distichous and usually absent from parts of the rachis..19. *C. sedoides* (R. Br.) Ag.

Locality.—Nat. Herb.: Newcastle (also Victoria). C.S. & I.R.: (also Queensland). Harv. Aus.: Kiama. Lucas (1936): 'All round coasts of Australia, and Tasmania.'

Central axis annularly constricted; ramuli distichous.

Central axis bears at each articulation two opposite, linear ramuli, which are seven times longer than broad ..... 20. *C. articulata* Harv.

Locality.—Lucas (1931): Plant as *C. Hodkinsonia* J. Ag., Richmond River.

Base of central axis bare of ramuli; ramuli opposite, usually obovate, always articulate ..... 21. *C. cactoides* (Turn.) Ag.

Locality.—Nat. Herb.: Eden (also Victoria). Lucas (1931): Richmond River.

Fronds simple, entire or slightly divided.

Fronds plane, entire or finely dentate, often giving rise, by proliferation, to secondary fronds from the lamina of the preceding leaf ..... This is the sub-genus *Phyllanthoideae* J. Ag.

Frond linear, obtuse at the tip, pedicellate at the base, not annulate; proliferations rare ..... 22. *C. parvifolia* Harv.

Locality.—Nat. Herb.: Kiama, Port Jackson, Port Stephens.

Frond elongated, plane or cylindrical, simple or dichotomous, rarely with proliferations ..... This is the sub-genus *Zosteroideae* J. Ag.

Base of frond annulate ..... 23. *C. flagelliformis* Ag.

Locality.—C.S. & I.R.: Plant as *C. ligulata* Harv., Botany Bay. University: Plant as *C. ligulata* Harv., Balmoral.

Genus 7. Acetabularia Lamour.

Inferior corona absent; superior composed of free knobs bearing hair tufts ..... 24. *A. peniculus* R. Br.

Locality.—Nat. Herb.: Plant as *Polyphysa peniculus* (R. Br.) Ag.,* Newcastle (also Victoria).

Inferior and superior corona present, both consisting of free processes, not united laterally to each other.

Sporangial rays with apiculate margins ..... 25. *A. crenulata* Lamour.

Locality.—Muell.: Richmond River (also Queensland).

Sporangial rays blunt, more or less scalloped at the margin, apiculum absent ..... 26. *A. calyculus* Quoy & Gaim.

Locality.—Nat. Herb.: Lake Macquarie, Newcastle (also Queensland). Lucas (1935): (also Lord Howe Island).

Genus 8. Microdictyon Decne.†

Colour pale green; branching opposite the rule ..... 27. *M. Agardhianum* Decne.

Locality.—Harv. Aus.: Port Jackson.

Colour very dark green; size large; habit irregular; branching alternate or opposite to some extent, but at intervals in the primary filaments in fours and fives from the same point ..... 28. *M. umbilicatum* (Velley) Zan.

Locality.—Nat. Herb.: Botany Bay, Port Stephens. C.S. & I.R.: Port Jackson.

Genus 9. Chaetomorpha Kuetz.

Filaments solitary or in tufts; plant attenuate at base; cells 0·15-0·50 mm. long and 1-2 times as long as broad; cylindrical filament slightly constricted between cells ..... 29. *C. aerea* (Dillw.) Kuetz.

Locality.—C.S. & I.R.: Bondi, Port Jackson, Curl Curl (also Queensland and Lord Howe Island). Harv. Aus.: (also Victoria). Laing: (also Norfolk Island).

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* Sub-genus *Polyphysa* has been accorded the rank of genus by some workers; good reason for not doing so is given by Solms-Laubach (1895).

† Prior to Setchell (1929) there existed much confusion in this genus, so that past specific determinations are now liable to be questioned.

Genus 10. RHIZOCLONIUM Kuetz.

Cells 1½-2½ times as long as broad; rhizoidal branches none or few, short, non-septate, and usually continuous with the cells from which they rise ..... 30. *R. implexum* Batt.*

Locality.—C.S. & I.R.: Plant as *R. tortuosum* Kuetz., Botany Bay, Port Jackson.

Genus 11. CLADOPHORA Kuetz.†

Plants forming thickened, cushion-like or rounded tufts ..... This is the sub-genus *Aegagropila* Kuetz.‡

Plants not united into spongy masses by rhizoidal or recurved branches; all branches similar, not increasing in size upwards; terminal cells short; adult cells not sub-dividing ..... This is the sub-genus *Eucladophora* Farlow.

Filaments attached throughout active life; fronds densely tufted, much branched, rigid; colour dark green; branches opposite or in fours, erect; ultimate ramuli short, blunt or slightly subulate; articulations at least three times as long as broad ..... 31. *C. rupestris* (Linn.) Kuetz.§

Locality.—C.S. & I.R.: Plant as *C. nuda* Harv., Botany Bay.

Fronds attached in irregular tufts when young, soon detached, floating.

Colour dull green; filaments somewhat irregularly, usually dichotomously, divided; branching often secund; ramuli blunt; cells 3-6 times as long as broad; dissepiments finally much contracted ..... 32. *C. fracta* (Dillw.) Kuetz.

Locality.—C.S. & I.R.: Stanwell Park.

Colour usually dark green; branching very rare; filaments 0·1-0·22 mm. wide; habit very near to *C. fracta* ..... 33. *C. chartacea* Grun.

Locality.—D.T.: Narrabeen Lagoon, near Port Jackson.

SYNONYMS.

Under the name of each accepted species are listed those synonyms which various workers have attributed to it. In each case a bracketed number then follows. This number indicates the authority quoted for the acceptance of the synonymy. The numbers and their corresponding references are:

(1) De Toni, 1889; (2) Harvey, 1858-1863; (3) Harvey, 1846-1851; (4) Lucas, 1912; (5) Solms-Laubach, 1895; (6) Setchell, 1929; (7) Weber Van Bosse, 1898; (8) Laing, 1927; (9) Lucas, 1936; (10) Newton, 1931; (11) Setchell and Gardner, 1920; (12) Sonder, 1871.

1. ENTEROMORPHA INTESTINALIS (Linn.) Link.

Enteromorpha africana Kuetz. (12)
lacustris Hassall (1)
minima Kuetz. (12)
spermatoidea Kuetz. (1)
Ulva Enteromorpha var. *intestinalis* Le Jol. (1)
intestinalis Linn. (1), (3), (11), (12)
Scytosiphon intestinalis Lyngb. (1), (3)
Fistularia intestinalis Grev. (1), (3)
Conferva intestinalis Roth. (1), (3)
'*Solenia Bertolini* Ag. (3)
intestinalis Ag. (3)
Ilea intestinalis Gaill. (3)
Tetraspora intestinalis Desv. (3)

Varieties include:
Ulva Enteromorpha var. *compressa* f. *Cornucopiae* Le Jol. (1)
Scytosiphon intestinalis var. *Cornucopiae* Lyngb. (1)

2. ENTEROMORPHA LINGULATA J. Ag.

Enteromorpha compressa var. *lingulata* (J. Ag.) Hauck. (1)
crinita Kuetz. ? nec *alior* (1)
Ulva capillaris Lamour. ? (1)
compressa Ag. ex parte (1)

3. ENTEROMORPHA COMPRESSA (Linn.) Grev.

Enteromorpha acanthophora Kuetz.' (12)
complanata Kuetz. (1), (12)
compressa Link. (2), (4)
fascia Postels & Ruprecht (11)

* Apparently this plant is extremely variable as Newton (England) says, 'filaments flaccid or lubricous . . . yellowish or light green', and Setchell and Gardner (America) say, 'filaments rigid . . . dark green'.

† Sonder (1880) lists *C. Woollsii* Sond. as from Parramatta River. This species is not mentioned by De Toni (1889).

‡ In the Lucas Collection, C.S. & I.R., Canberra, is a plant labelled *Cladophora* (*Aegagropila*) *annectens* Lucas. No description has been found and it is thought Professor Lucas had intended publishing a new species description. The locality given was Manly.

§ Newton (1931) includes *C. nuda* Harv. as a variety of *C. rupestris* (Linn.) Kuetz.

' De Toni regards this as a synonym of *Ulva Linza* Linn. This authority has been followed.

Enteromorpha fulvescens Kuetz. (12)
Novae-Hollandiae Kuetz. (12)
paradoxa Kuetz. (12)
prolifera S. & G. (part) (11)
ramulosa Kuetz. (12)
spinescens Kuetz. (12)
Ulva compressa Linn. (1), (3), (11)
Enteromorpha var. *compressa* Le Jol. (1)
Scytosiphon compressus Lyngb. A partim (1), (3)
Conferva compressa Roth. excl. var. (1), (3)
Ilea compressa Gaill. (1), (3)
Solenia compressa Ag. (3)
Fistularia compressa Grev. (3)
Varieties include:
Enteromorpha compressa Aresch. (1)
Enteromorpha compressa Crouan (1)

4. ENTEROMORPHA PROLIFERA (Muell.) J. Ag.

Enteromorpha compressa var. *prolifera* Grev. (1)
intestinalis f. *prolifera* Hauck. (1)
pilifera Kuetz. (1)
tubulosa var. *pilifera* Ahln. (1)
Ulva compressa var. *prolifera* Ag. (1)
crinita Mert. non Roth. (1)
prolifera Muell. (1), (11)
Scytosiphon compressus var. *crispatus* Lyngb. (1)

5. ULVA LINZA Linn.

Ulva Bertolonii Ag. (1)
crispata Bertol. (1)
Enteromorpha var. *lanceolata* Le Jol. (1)
Lactuca forma *genuina* Tilden (not of Hauck.) (11)
Enteromorpha Bertolonii Mont. (1)
Linza (Linn.) J. Ag. (1)
Solenia Bertolonii Ag. (1)
Linza Ag. (1), (3)
Phycoseris crispata Kuetz. (1)
lanceolata Kuetz. (1)
**Linza* Kuetz. (3)
olivacea Kuetz. (1)
planifolia Kuetz. (1)
smaragdina Kuetz. (1)
Ilea Bertolonii De-Not. (1)
Tremella marina fasciata Dillw. (3)

7. ULVA LACTUCA Linn.

Ulva rigida Ag. (4)
Varieties include:
Ulva Australis Kuetz. (1)
fimbriata Welw. (1)
laciniata Wulf. (1)
Lactuca Wulf. (1)
lapathifolia Aresch. (1)
latissima J. Ag. (10)
latissima Linn. ex parte, nec Grev. (1)
latissima var. *palmata* Ag. (1)
latissima var. *umbilicalis* Ag. (1)
myriotrema Crouan (1), (10)
Ulva reticulata Salzm. et auct. nonnull., non Forsk. (1)
rigida Ag. (1), (10)
rigida var. Welw. (1)
Phycoseris australis Kuetz. (1)
lacinulata Kuetz. (1)
lapathifolia Kuetz. ? (1)
Linza Kuetz. (1)
myriotrema Lenorm. (1)
rigida Kuetz. (1)

9. BRYOPSIS PLUMOSA (Huds.) Ag.

Bryopsis abietina Kuetz. (1)
Arbuscula Lamour. (1)
Lyngbyei Horn. (1)
Lyngbyei Fl. Dan. (3)
Ulva plumosa Huds. (1), (3), (11)
Varieties include:
Bryopsis plumosa Grev. (1)

10. VAUCHERIA DICHOTOMA (Linn.) Ag.

Vaucheria globifera De-Bary (1)
piriformis Kuetz. (1)
salina Kuetz. (1)
Conferva dichotoma Dillw. (1)
dichotoma Linn. (1)
Plinii Setis porcinis Ray (1)
Varieties include:
Vaucheria bursata var. *marina* Kuetz. (1)
Pilus Martens (1)
submarina Berk. (1), (3)

11. CODIUM ADHAERENS (Cabr.) Ag.

Codium arabicum Kuetz. (1)
difforme Kuetz. (1)
Agardhia adhaerens Cabr. (1), (3)
Spongodium adhaerens Lenorm. (1)
cristatum Bory (1)

14. CODIUM DECORTICATUM (Woodw.) Howe.

Codium elongatum Ag. (9)
Ulva decorticata Woodw. (11)

15. CODIUM MUELLERI Kuetz.

Codium tomentosum var. *australasicum* Aresch. ex parte (1)

16. CODIUM FRAGILE (Suring.) Heriot.

Codium mucronatum J. Ag. (9), (11)
tomentosum Tilden (not Stackh.) (11)
Acanthocodium fragile Suring. (1), (11)

17. CAULERPA HYPNOIDES (R.Br.) Ag.

Caulerpa flexilis Lamour. (7), (9)
flexilis J. Ag. (7)
Muelleri Sond. (7) (9)
Turneri Lamour. (1), (7)
Fucus hypnoides R.Br. (1), (2), (7)
Chauvinia flexilis Kuetz. (7)
hypnoides Kuetz. (1), (2), (7)

18. CAULERPA SCALPELLIFORMIS (R.Br.) Ag.

Caulerpa denticulata Decne. (7)
Fucus scalpelliformis R.Br. (1), (2), (7)

* De Toni regard this as a synonym of *U. Lactuca* Linn. This authority has been followed.

19. Caulerpa sedoides (R.Br.) Ag.

Caulerpa lactevirens J. Ag. (not Mont.) (8)
Fucus sedoides R.Br. (1), (2), (7), (12)
Chauvinia sedoides Kuetz. (1), (2), (7)
Ahnfeldtia sedoides Trev. (2)
Varieties include:
Caulerpa geminata Harv. (2)

20. Caulerpa articulata Harv.

Caulerpa Hodkinsonia J. Ag. (7)

21. Caulerpa cactoides (Turn.) Ag.

Caulerpa corynephora Mont. (1?), (2)
Fucus cactoides Turn. (1), (2), (7)
Chauvinia cactoides Kuetz. (1), (2), (7)
Tricladia australis Decne. (1), (7)
Ahnfeldtia cactoides Trev. (2)
corynephora Trev. (2)

23. Caulerpa flagelliformis Ag.

Caulerpa filiformis Hering. (1), (7)
ligulata Harv. in J. Ag. (7)
Phyllerpa flagelliformis Kuetz. (1), (7)
Amphibolis filiformis Suhr. (1), (7)

24. Acetabularia peniculus R.Br.

Polyphysa aspergillosa Lamour. (1), (2), (5)
australis Lamarck. (1), (2)
Fucus Peniculus R.Br. (1), (2), (5)
Varieties include:
Polyphysa Cliftoni Harv. (5)

25. Acetabularia crenulata Lamour.

**Acetabularia caraibica* Kuetz. (12)
integra var. *minor* Froelich. (12)
* *major* Mart. Preuss. (12)
Tubularia Acetabulum var. B. Gmel. (1)

26. Acetabularia Calyculus Quoy & Gaimard.

Cliftonella Calyculus J. E. Gray (2)

27. Microdictyon Agardhianum Decne.

Microdictyon tenue J. E. Gray (6)
tenuius J. E. Gray (6)
† *umbilicatum* (Velley) Zan. (1)
† *Velleyanum* Decne. (1), (2)
†*Conferva umbilicata* Velley (1), (2)
†*Hydrodictyon umbilicatum* Ag. (1), (2)

28. Microdictyon umbilicatum (Velley) Zan.

† *Microdictyon Agardhianum* Decne. (1), (4)
tenuis var. *australis* J. Ag. in part (6)
Velleyanum Decne. in part (1), (6)
Conferva umbilicata Velley (1), (6)
Hydrodictyon umbilicatum Ag. in part (1), (6)

29. Chaetomorpha aerea (Dillw.) Kuetz.

Chaetomorpha baltica Kuetz. (10)
Dubyana Kuetz. (1)
Chaetomorpha gallica Kuetz. (1)
herbacea Kuetz. (1)
intermedia in Erb. (1)
princeps Kuetz. (1)
urbica Kuetz. (1)
variabilis Kuetz. (1)
vasta Kuetz. (1)
Diplonema intermedium De-Not. (1)
spectabile De-Not. (1)
Conferva aerea Dillw. (1), (10), (11)
antennina Bory (3)
Dubyana Kuetz. (1)
princeps Kuetz. (1)
urbica Zan. (1)
variabilis Kuetz. (1)
vasta Kuetz. (1)

30. Rhizoclonium implexum Batt.

Rhizoclonium implexum Kuetz. (1)
rigidum Gobi. (10)
tortuosum Kuetz. (10)
Conferva implexa Harv. (1)
implexa Dillw. (10)
intricata Grev. (1)
tortuosa Dillw. (11)
Bangia Johnstonii Grev. (1)
Chaetomorpha tortuosa Kuetz. (11)

31. Cladophora rupestris (Linn.) Kuetz.

Cladophora Lyngbyeana Phyc. germ. (1)
Conferva glauca Roth. (1), (3)
rupestris Linn. (1), (3)
virgata Roth. (1), (3)
Ceramium rupestre DC. (1)
Varieties include:
Cladophora nuda Harv. (10)

32. Cladophora fracta (Dillw.) Kuetz.

Conferva divaricata Roth. (3)
flavescens Wyatt (3)
fracta Fl. Dan. (3)
hirta Fl. Dan. (3)
vagabunda Huds. (3)
Varieties include:
Cladophora crispata Hassall (1)
flavescens Harv., non Kuetz. (10)
flexuosa Batt. (10)
gossypina Kuetz. (1)
heterocladia Kuetz. (1)
rigidula Kuetz. (1)
strepens Kuetz. (1)
viadrina Kuetz. (1)
Conferva angulosa Pollini sec Kuetz. ? (1)
capillaris Mont. (1)
fracta Dillw. (1)
fracta a patens Kuetz. (1)
gossypina Drap. (1)
heterocladia Kuetz. (1)
pilosa Aresch. (1)
ramosa Beggiat (1)
strepens Ag. (1)

* This synonymy is no longer accepted, following Solms-Laubach (1895).
† This synonymy is no longer accepted, following Setchell (1929).

An alphabetical list of the synonyms attributed to the whole, or to part of, species mentioned in the key, has been prepared. Opposite each name is the number of the accepted species as listed in the key, e.g., *Acanthocodium fragile* Suring .. 16 indicates *Codium fragile* (Suring.) Heriot.

Acanthocodium fragile Suring. 16
Acetabularia integra var. *minor* Froelich. 25
Agardhia adhaerens Cabr. .. 11
Ahnfeldtia cactoides Trev. .. 21
corynephora Trev. 21
sedoides Trev. 19
Amphibolis filiformis Suhr. 23
Bangia Johnstonii Grev. .. 30
Bryopsis abietina Kuetz. .. 9
Arbuscula Lamour. 9
Lyngbyei Horn. 9
Lyngbyei Fl. Dan. 9
plumosa Grev. 9
Caulerpa corynephora Mont.? 21
denticulata Decne. 18
filiformis Hering. 23
flexilis Lamour. 17
flexilis J. Ag. 17
geminata Harv. 19
Hodkinsonia J. Ag. 20
laetevirens J. Ag. (not Mont.) 19
ligulata Harv. in J. Ag. .. 23
Muelleri Sond. 17
Turneri Lamour. 17
Ceramium rupestre DC. .. 31
Chaetomorpha baltica Kuetz. 29
Dubyana Kuetz. 29
gallica Kuetz. 29
herbacea Kuetz. 29
intermedia in Erb. 29
princeps Kuetz. 29
tortuosa Kuetz. 30
urbica Kuetz. 29
variabilis Kuetz. 29
vasta Kuetz. 29
Chauvinia cactoides Kuetz... 21
flexilis Kuetz. 17
hypnoides Kuetz. 17
sedoides Kuetz. 19
Cladophora crispata Hassall 32
flavescens Harv. non Kuetz. 32
flexuosa Batt. 32
gossypina Kuetz. 32
heterocladia Kuetz. 32
Lyngbyeana Phyc. germ. 31
nuda Harv. 31
rigidula Kuetz. 32
strepens Kuetz. 32
viadrina Kuetz. 32
Cliftonella Calyculus J. E. Gray 26
Codium arabicum Kuetz. .. 11
difforme Kuetz. 11
elongatum Ag. 14
mucronatum J. Ag. 16
tomentosum var. *australisicum* Aresch. ex parte .. 15
Codium tomentosum Tilden (not Stackh.) 16
Conferva aerea Dillw. 29
angulosa Pollini sec Kuetz.? 32
antennina Bory 29
capillaris Mont. 32
compressa Roth. excl. var. 3
dichotoma Dillw. 10
dichotoma Linn. 10
divaricata Roth. 32
Dubyana Kuetz. 29
flavescens Wyatt 32
fracta Fl. Dan. 32
fracta Dillw. 32
fracta a patens Kuetz. .. 32
glauca Roth. 31
gossypina Drap. 32
heterocladia Kuetz. 32
hirta Fl. Dan. 32
implexa Harv. 30
implexa Dillw. 30
intestinalis Roth. 1
intricata Grev. 30
pilosa Aresch. 32
Plinii Setis porcinis Ray.. 10
princeps Kuetz. 29
ramosa Beggiat 32
rupestris Linn. 31
strepens Ag. 32
tortuosa Dillw. 30
umbilicata Velley 28
urbica Zan. 29
vagabunda Huds. 32
variabilis Kuetz. 29
vasta Kuetz. 29
virgata Roth. 31
Diplomena intermedium De-Not. 29
spectabile De-Not. 29
Enteromorpha acanthophora Kuetz. 3
africana Kuetz. 1
Bertolonii Mont. 5
complanata Kuetz. 3
compressa Link. 3
compressa Aresch. 3
compressa Crouan 3
compressa var. *lingulata* (J. Ag.) Hauck. 2
compressa var. *prolifera* Grev. 4
crinita Kuetz.? nec alior.. 2
fascia Postels & Ruprecht 3
fulvescens Kuetz. 3
intestinalis f. *prolifera* Hauck. 4
lacustris Hassall 1
Linza (Linn.) J. Ag. .. 5
minima Kuetz. 1
Enteromorpha Novae-Hollandiae Kuetz. 3
paradoxa Kuetz. 3
pilifera Kuetz. 4
prolifera S. & G. (part).. 3
ramulosa Kuetz. 3
spermatoidea Kuetz... .. 1
spinescens Kuetz. 3
tubulosa var. *pilifera* Ahln. 4
Fistularia compressa Grev... 3
intestinalis Grev. 1
Fucus cactoides Turn. 21
hypnoides R. Br. 17
Peniculus R. Br. 24
scalpelliformis R. Br. .. 18
sedoides R. Br. 19
Hydrodictyon umbilicatum Ag. (part) 28
Ilea Bertolonii De-Not. .. 5
compressa Gaill. 3
intestinalis Gaill. 1
Microdictyon tenue J. E. Gray 27
tenuis var. *australis* J. Ag. in part 28
tenuius J. E. Gray 27
Velleyanum Decne. (part) 28
Phycoseris australis Kuetz. 7
crispata Kuetz. 5
lacinulata Kuetz. 7
lanceolata Kuetz. 5
lapathifolia Kuetz.? 7
Linza Kuetz. 7
myriotrema Lenorm. .. 7
olivacea Kuetz. 5
planifolia Kuetz. 5
rigida Kuetz. 7
smaragdina Kuetz. 5
Phyllerpa flagelliformis Kuetz. 23
Polyphysa aspergillosa Lamour. 24
australis Lamarck 24
Cliftoni Harv. 24
Rhizoclonium implexum Kuetz. 30
rigidum Gobi. 30
tortuosum Kuetz. 30
Scytosiphon compressus Lyngb. A partim 3
compressus var. *crispatus* Lyngb. 4
intestinalis Lyngb. 1
intestinalis var. *Cornucopiae* Lyngb. 1
Solenia Bertolonii Ag. 5
compressa Ag. 3
intestinalis Ag. 1
Spongodium adhaerens Lenorm. 11

Spongodium cristatum Bory 11
Tetraspora intestinalis Desv. 1
Tremella marina fasciata Dillw. 5
Tricladia australis Decne. .. 21
Tubularia Acetabulum var. B. Gmel. 25
Ulva australis Kuetz. 7
Bertolonii Ag. 5
capillaris Lamour. ? .. 2
compressa Ag. ex parte .. 2
compressa Linn. 3
compressa var. *prolifera* Ag. 4
crinita Mert. non Roth. .. 4
crispata Bertol. 5
decorticata Woodw. 14
Ulva Enteromorpha var. *compressa* Le Jol. 3
var. *compressa* f. *Cornucopiae* Le Jol. 1
var. *intestinalis* Le Jol. 1
var. *lanceolata* Le Jol... 5
fimbriata Wellw. 7
intestinalis Linn. 1
laciniata Wulf. 7
lactuca forma *genuina* Tilden (not of Hauck.) 5
lactuca Wulf. 7
lapathifolia Aresch. 7
latissima J. Ag. 7
latissima Linn. ex parte nec Grev. 7
Ulva latissima var. *palmata* Ag. 7
var. *umbilicalis* Ag. .. 7
myriotrema Crouan 7
plumosa Huds. 9
prolifera Muell. 4
reticulata Salzm. et auct. nonnull., non Forsk. .. 7
rigida Ag. 7
rigida var. Welw. 7
Vaucheria bursata var. *marina* Kuetz. 10
globifera De-Bary 10
Pilus Martens 10
piriformis Kuetz. 10
salina Kuetz. 10
submarina Berk. 10

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UPPER DEVONIAN SEDIMENTS AT MT. LAMBIE, N.S.W.

By Ida A. Brown,* D.Sc., and Germaine A. Joplin, B.Sc., Ph.D.

(Two Text-figures.)

[Read 27th July, 1938.]

Mount Lambie, near Rydal, is generally regarded as a type area for Upper Devonian sediments in New South Wales, as the region was first examined geologically by the Rev. W. B. Clarke in 1841. Since then reports have been made by various geologists, although no very detailed map of the district has been made, other than that of C. S. Wilkinson (1875), whose estimated thickness of the sediments is frequently quoted.

Parliamentary Reports by W. B. Clarke and S. Stutchbury from 1852 onwards make reference to *Spirifer* sandstones at Mt. Lambie.

In 1875 the Department of Mines, New South Wales, published a "Geological Map of the Districts of Hartley, Bowenfels, Wallerawang and Rydal" by C. S. Wilkinson. The map is accompanied by notes and a geological section from Mt. Lambie to Mt. Walker, indicating a thickness of about 10,000 feet of Upper Devonian sediments. The notes include records of the localities of Devonian fossils, e.g., Note 11, at Solitary Creek, near the new Bathurst Road, "Thin bedded sandstones and sandy shales dip S. 35°E. at 10° full of Devonian Mollusca, Spirifera, Rhynchonella, Pecten, Orthis, Murchisonia, Modiola, Corals and Encrinite Stems". *Lepidodendron* had been discovered in January, 1875, by the Rev. W. B. Clarke (1878), "in a creek near Rydal, on a spur of the Mt. Lambie Range, where Devonian Brachiopoda occur".

Professor T. W. E. David (1893) made reference to the Upper Devonian rocks of Rydal and published a sketch-geological section from Mt. Lambie to Rydal.

Prof. David and Mr. E. F. Pittman published two papers (1893*a*, 1893*b*) on the occurrence of *Lepidodendron* at Mt. Lambie, near Rydal, noting its association with marine fossils.

These are the principal published accounts based on actual geological field-work in the area, although frequent reference to Mt. Lambie or Rydal is made elsewhere, especially with regard to the estimated thickness of 10,000 feet of Upper Devonian sediments (Sussmilch, 1914; B.A.A.S. Handbook, 1914; Benson, 1922; Encyc. Britt., 14th Ed., 1929; David, 1932, etc.).

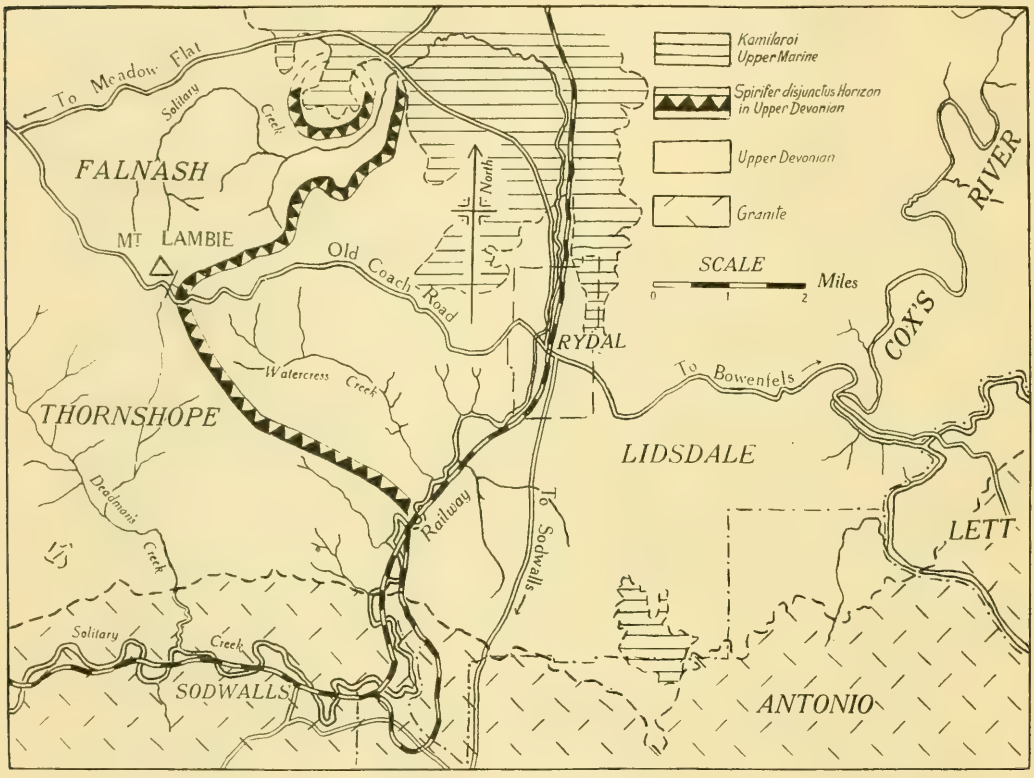
The purpose of the present paper is to place on record the results of field-investigations carried out by the writers during 1931 and 1935, particularly with regard to the geological structure and thickness of the Upper Devonian sediments.

Structure and Thickness of Devonian Beds.

Upper Devonian sediments outcrop in the vicinity of Rydal, and occur as a broad syncline with an almost meridional axis and a very slight pitch to the south. In the northern part of the area they are overlain by almost horizontally-bedded,

* Work carried out during the tenure of a Linnean Macleay Fellowship of the Society.

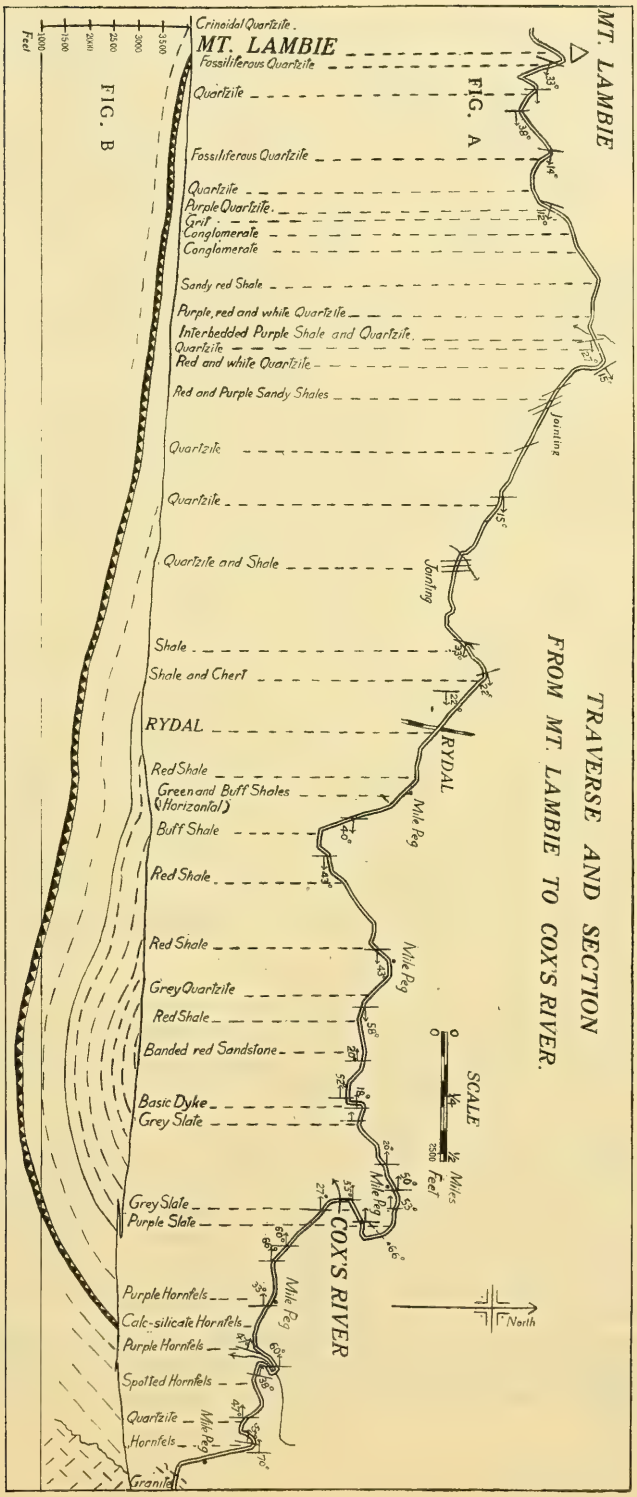
coarse sediments of the Upper Marine Stage of the Permian system. On the east, south and west they have been intruded by an irregular mass of granite, portion of the Bathurst–Hartley–Mt. Werong bathylith. The granite boundary against the Devonian sediments was mapped in 1924 by Mr. F. Jardine, to whom we are indebted for permission to indicate this boundary on the accompanying map (Text-fig. 1).



Text-fig. 1.—Sketch-Map of Mt. Lambie–Rydal district.

The Upper Devonian sediments are essentially marine, consisting of thin-bedded conglomerates and sandstones, interbedded with fine-grained, dark red shales and mudstones. Earth movements subsequent to their deposition have induced an almost vertical cleavage in the mudstones, without affecting the more competent associated sandstones and quartzites.

Great thicknesses of the sediments are quite unfossiliferous. Close to the Mt. Lambie Trigonometrical Station, however, and stratigraphically low in the marine sequence, is a bed containing quantities of crinoidal remains; a short distance to the east, and stratigraphically above, is a bed of fossiliferous quartzite about 15 inches in thickness, closely packed with internal moulds and external casts of marine forms, chiefly *Spirifera disjuncta*, *Rhynchonella pleurodon* and some lamellibranchs and gastropods. This fossil band forms a good datum horizon, which has been traced (see map, Text-fig. 1) from near the junction of the old



Text-fig. 2.—Traverse and section from Mt. Lambie to Cox's River.

and new railway lines between Sodwalls and Rydal, north-westerly towards the summit of Mt. Lambie and thence north-easterly to the road-metal quarries of Solitary Creek, near the new Bathurst Road. Circumstances prevented us from making a contour map of the area, but when due allowance is made for the physiography it is found that the outcrop of the fossiliferous horizon is that of an almost plane bed, dipping slightly south of east at an angle of only 8 degrees.

In the eastern portion of the syncline the fossiliferous horizon outcrops on the flanks of Mt. Flaherty and Mt. Walker, and dips to the west: this portion of the outcrop has not been mapped in detail.

Natural sections of the Upper Devonian sediments are rarely obtainable, although fairly good shallow sections occur in the railway and road cuttings. These sections show that the dips of the beds are not great except in the vicinity of the granite contacts. Some sections show minor folds and faults, but no major faulting has been observed. The sediments have been hornfelsed near the granite contacts and compare with similar types at Hartley. At Hartley the Spirifer-bearing quartzites give rise to wollastonite-quartz-hornfelses at the immediate contact and further away to calc-silicate types without wollastonite. These are usually associated with "purple-hornfelses" which appear to be the metamorphic equivalents of the intercalated red shales of Rydal (Joplin, 1935, 1936).

Text-figure 2, A, shows a detailed traverse of about nine miles along the old coach road over Mt. Lambie to Rydal and thence along the Bowenfels Road to beyond the Cox's River. The dips along the western limb of the fold are small, but those of the eastern limb are greater owing to the granite intrusion; inter-bedded with more competent sandstone or quartzite are bands of red shale, which in places are strongly cleaved, giving a false appearance of highly inclined strata.

Text-figure 2, B, is a vertical section across the syncline from Mt. Lambie to the Cox's River, in the direction of true dip of the beds, constructed by projecting the measurements of the dips and elevations in the traverse, figure A, on to an east–west vertical plane through Rydal. The position indicated for the fossiliferous horizon was obtained by projecting the positions of its occurrences at Solitary Creek to the north and near Sodwalls to the south on to the vertical plane (figure B) and taking a mean position. The surface dips appear to be slightly greater than the general dip of the fossiliferous horizon. The thickness of sediments above the *Spirifer* bed is thus seen to be about 2,500 feet, which we believe to be a more accurate evaluation than Wilkinson's former estimate of 10,000 feet.

It should be pointed out that underlying the sediments to the west of Mt. Lambie are fine-grained igneous rocks, which are possibly flows at the base of the Upper Devonian Lambie series. Their field-relations are obscure and, their petrology has not been critically studied.

Other Occurrences.

An investigation by one of us (I.A.B., 1931) of the Upper Devonian rocks of the South Coast of New South Wales led to a study of the distribution and occurrence of Devonian rocks throughout South-eastern Australia.

It was found that on the South Coast the Upper Devonian rocks might be divided into three stages:

(i) a lower, volcanic (Eden) stage of acid igneous rocks, 450 feet to 800 feet in thickness,

(ii) a middle (Yalwal) stage of terrestrial or estuarine sediments with inter-bedded contemporaneous flows of basalts and rhyolites, having a maximum thickness of 1,500 feet, and

(iii) an upper, marine stage of quartzites, grits, conglomerates and mudstones, lithologically and palaeontologically equivalent to the Upper Devonian sediments of Mt. Lambie, for which the name Lambie stage was suggested. On the South Coast sediments of this stage have a maximum thickness of 1,200 feet.

It was the apparently great variation in the thickness of the Lambie stage, constituting only the upper portion of the Upper Devonian, which led to a re-examination of the type area.

Rocks of the Lambie stage are widespread in New South Wales and have been described from many localities, including Molong–Canoblas (C. A. Sussmilch, 1906), Upper Macquarie (L. F. Harper, 1909), Forbes–Parkes (E. C. Andrews, 1910), Cobar and Canbelego (E. C. Andrews, 1913*a*, 1913*b*), Wellington (A. J. Matheson, 1930), Hartley (G. A. Joplin, 1935) and west of Molong (Joplin and Culey, 1937). Other occurrences are recorded in Reports of the Geological Survey of the Mines Department of New South Wales.

The widespread distribution of the deposits indicates a general flooding of this portion of the continent by ocean waters during late Devonian time, and whilst undoubtedly great thicknesses of sediment were laid down in some portions, it seems improbable that the thickness of the (Lambian) Upper Devonian sediments in the vicinity of Rydal was ever much greater than 2,500 feet.

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AN ALBINO-FORM OF *MACROZAMIA SPIRALIS* Miq.

By Valerie May, B.Sc., Commonwealth Research Scholar in Botany, University of Sydney.

(Two Text-figures.)

[Read 27th July, 1938.]

The seeds of *Macrozamia spiralis* Miq. are not dispersed far from the parent, so that a female plant becomes surrounded by a colony of its offspring. In one such colony of about 40 individuals—at Narrabeen, a few miles north of Sydney, New South Wales—two of the young cycads were white. The pinnae were fully unfolded, and the petioles were not abnormally long. There was therefore no question of the white seedlings being etiolated. That the lack of chlorophyll was not due to the habitat is shown by the presence of normal (green) seedlings on all sides under similar conditions. It seems highly probable that albinism in this

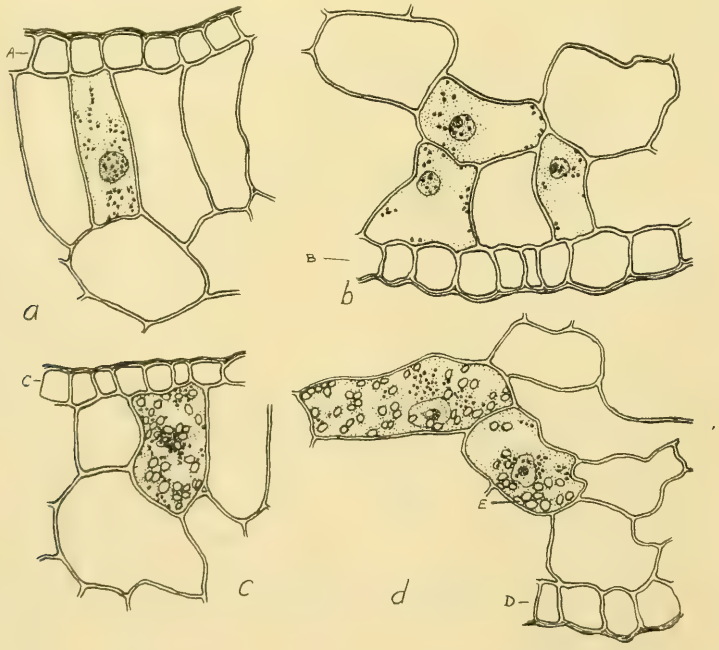


Fig. 1.

a, *b*.—Palisade cells and mesophyll of a pinna of the albino-form. A, upper epidermis. B, lower epidermis. (× 300.)

c, *d*.—Palisade cells and mesophyll of a pinna of the normal form. C, upper epidermis. D, lower epidermis. E, plastids. (× 300.)

instance is the result of a plastid deficiency in the cytoplasm of the egg or of a gene mutation. The production by a single plant of two albino-forms, apparently of different age, suggests that there have been two independent instances of plastid deficiency, or that the female parent is heterozygous with respect to the production of chlorophyll. If the albinism is due to heterozygosity of the female plant, some of the fertilizing pollen was derived from a plant also heterozygous as regards this factor. This seems a more plausible suggestion than that a dominant albino mutation has occurred twice in one plant within a few years.

Figure 2 shows the larger of the albino plants. This plant still possessed stored starch in the endosperm. It will be of interest to know the size attained by the other (undisturbed) albino before it exhausts the food-stores of the seed; at this stage the factor preventing chlorophyll formation, and so photosynthesis, will prove lethal.

Fig. 2.—Photograph of albino *Macrozamia.* (× $\frac{1}{5}$.)

Part of the cross-section of a pinna of an albino is shown in figure 1, *a*, *b*. Figure 1, *c*, *d*, shows corresponding part of a green pinna. The albino differs from the normal, not only in the absence of chlorophyll, but in the absence of the plastids themselves; no other observable difference was noted in these sections. Sections of the abaxial surfaces of albino and normal pinnae showed no difference between the mean number of stomata per unit area.

The plants described above were found by students working under the writer's direction at the Field Station of the Sydney University Biological Society.

STUDIES IN AUSTRALIAN EMBIOPTERA.

PART III: REVISION OF THE GENUS METOLIGOTOMA, WITH DESCRIPTIONS OF NEW SPECIES, AND OTHER NOTES ON THE FAMILY OLIGOTOMIDAE.

By Consett Davis, M.Sc., Macleay Fellow of the Society in Zoology.

(120 Text-figures and 3 Maps.)

[Read 31st August, 1938.]

Since the completion of Parts i and ii of this series (Davis, 1936*a*, *b*), a considerable amount of fresh material has been obtained, particularly of the genus *Metoligotoma*, and this has necessitated the preparation of a further systematic paper, both to describe new forms and to modify certain descriptions given in the earlier papers. In particular, a study of series of specimens belonging to the genus *Metoligotoma* from numerous localities has shown which characters possess variations of taxonomic importance, so that it has become necessary to divide into several species those forms previously classed as *M. reducta reducta* Davis.

The specific descriptions have been somewhat modified as a result of experience. The head-breadth has been added to the list of measurements, as being a more reliable factor than head-length, which is influenced by the position of the labrum in each individual when examined. For each measurement (total length, head-length and head-breadth) only the maximum and minimum for the available material is given, the average for the series not being regarded of sufficient significance to merit calculation. The data for the ratio head:thorax:abdomen have also been omitted, as showing too great a divergence in members of any one series, depending on the degree of contraction of the body. The normal number of segments for complete antennae seems to vary; therefore, the numerical limits have been given for what seem to be undamaged antennae, the lower limit based on the occurrence of several individuals with an equal number of segments on both sides and with the terminal segments smoothly rounded. Antennal length is given as a ratio of the head-breadth, not as a maximum absolute length. For each series, the numbers of adult specimens of both sexes examined for taxonomic purposes are given.

In addition to the size limits for both sexes, and a description of the colour of the darkest (i.e. most fully matured) specimens, only the head-outline and terminalia of the males are described. Other characters, such as the mandibles, tergites (except those included in the male terminalia), legs, female terminalia, etc., are of no taxonomic importance specifically in the genus *Metoligotoma*, and are similar to the structures described in the earlier papers of this series.

Details of the colour and size of females have been included, when available, and female allotypes and paratypes have been named. However, no characters have been found whereby the females can be determined specifically, and it seems that in this Order a description based on the male alone is likely to be

as useful as one based on an examination of both sexes. Descriptions based on the female alone are worthless.

The figures in this paper are from camera lucida outlines. Colour descriptions are based on the appearance, under the binocular microscope, of alcoholic material. Living material often appears darker to the naked eye. Measurements were made with a calibrated ocular micrometer, and are exclusive of appendages. Unless otherwise stated, all the localities are in New South Wales, and all material was collected by the author.

Genus Metoligotoma Davis, 1936.

Proc. Linn. Soc. N.S.W., lxi (5), 1936, p. 248.

The original generic description must be slightly modified in the light of additional material, but the genus appears to be a natural one, certain characters peculiar to it being practically unchanged throughout the entire range of its constituent species. The modified description is as follows:

Wingless Oligotomidae, the males possessing the following characters: Left cercus one-segmented, due to the complete fusion of the two larval segments, the resulting structure bearing minute nodules on its inner face; first segment of right cercus reduced to a broad base for the accommodation of the second segment; left hemitergite of tenth abdominal segment produced backwards to a process from its inner margin; right hemitergite with a dorsal foliaceous process projecting inwards in a more or less horizontal plane; hypandrium produced backwards on the right-hand side to a slender, tapered process, between which and the body of the hypandrium lies a subtriangular plate. Both sexes with two minute bladders placed ventrally on the first segment of the hind tarsi, and one bladder on the second segment.

The form of the process of the left hemitergite was formerly described as slender and sinuous; this does not fit all the species. The left cercus-basipodite, originally described as a small free sclerite, is in some cases quite massive, and often largely membraneous. The form of the appendages of the hypandrium has been added to the former description, as being peculiar to the genus as at present constituted, and constant in all its members.

Metoligotoma reducta Davis, 1936. Figs. 1–4.

M. reducta reducta Davis, Proc. Linn. Soc. N.S.W., lxi (5), pp. 248–250 (pars).

Under the above heading I previously included what is now shown to be an assemblage of several different species. The name *M. reducta* must now be confined to those specimens agreeing with the holotype, which was collected at Elanora, near Narrabeen (Map 1, 1A). Specimens from the other localities listed (l.c., p. 250), some of which were at the time designated paratypes, are transferred to other species, as detailed later. In view of the error which has been introduced, the term paratype is restricted in future to specimens from the locality of the holotype exactly agreeing with it in structural detail. As the original description and figures do not conform to the name in the strict sense, a revised description of *M. reducta* is appended.

♂. Length 6·7–11·5 mm.; head, length 1·44–2·37 mm., breadth 1·18–1·92 mm. Length of apparently complete antennae 2·3 to 3·5 times the corresponding head-breadth, with 16–20 segments. *Colour*: Head, including eyes, black; thoracic and abdominal tergites dark brown (almost black), not shiny. Pleurites very dark brown. Sternites dark brown, almost black, except the anterior abdominal sternites, which are somewhat paler medially. Segments of antennae golden-

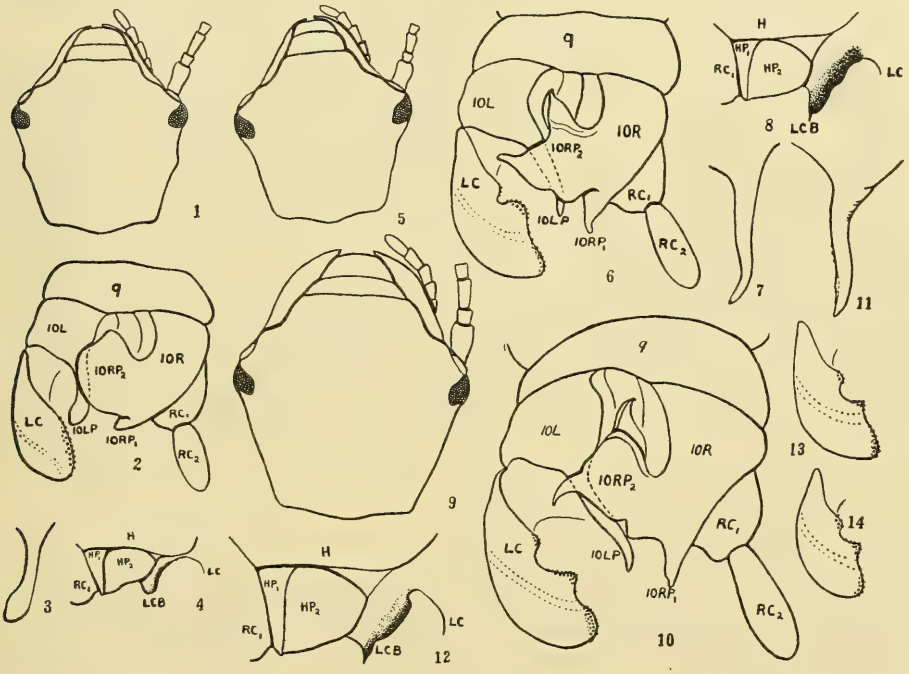
brown; segments of legs dark brown, with noticeable cream-coloured portions near the joints. Cerci pale golden-brown. Intersegmental membranes (little visible) cream. *Head*: As in all species in which a long series was examined, the largest head-capsules are well-formed, and show specific characters, but the smaller head-capsules retain, to a greater or less extent, the rounded facies of the larval capsule. Although this fact discounts the use of the head-capsule outline as a taxonomic feature, the outline of the largest head-capsules for each species is described and figured. In *M. reducta* (fig. 1) the head is widest at the eyes (as in all species), and the sides run backward to the posterior limits, converging strongly. A marked lump occurs on each side approximately midway between the eyes and the posterior angles, which are obtusely rounded. *Terminalia* (figs. 2, 3, 4): Ninth abdominal tergite (9) shorter than the preceding tergites, slightly asymmetrical. Tenth tergite divided into left and right hemitergites, the right (10R) massive, subtriangular, terminating distally in a rounded process ($10RP_1$) projecting inwards and downwards. 10R with a dorsal process ($10RP_2$), foliaceous, smoothly rounded, projecting to the left and slightly forward in a more or less horizontal plane. Left hemitergite (10L) subtriangular, produced to a slender backwardly-directed process (10LP) from its inner margin. 10LP terminally curving to the left and downwards, ending in a suboval plate, wider than the immediately proximal part of 10LP. Basally, the area between 10L and 10R is occupied by several smaller sclerites. Right cercus normal for the genus, the first segment (RC_1) broader than long, fused to the outer side of 10R, and serving as a base for the second segment (RC_2), which is subcylindrical. Left cercus (LC) one-segmented, approximately pyriform in dorsal view, with minute teeth on its inner face. Especially in specimens observed soon after the last ecdysis, the former division of the cercus into two segments is clearly indicated as a paler line running obliquely across the fused structure, separating off the outer and distal portion from the remainder, the larval first segment. Ventrally, the hypandrium (H), a large plate, is produced backwards from its right-hand margin to a tapered process (HP_1), the space between this and the body of the hypandrium being filled by a subtriangular plate (HP_2). Left cercus-basipodite (LCB) bluntly rounded distally, membraneous except along the outer (left) side and at the distal extremity.

Ventral to $10RP_2$, and arising from 10R, is a broad, tapered process, membraneous laterally, usually projecting downwards and invisible in dorsal view. In other species of this genus its description is omitted, as it is of no systematic importance. It occurs in the males of all species of the genus. In earlier papers it was suggested that this structure might be the aedeagus (see, e.g., Davis, 1936*a*, fig. 10, A; 1936*b*, fig. 4, A), but a closer examination of its origin, position and attachment, and a study of the internal anatomy of the males of the genus, discount this surmise. It is to be regarded as an inferior appendage of 10R.

Thirty-three males of this species from the type locality have been examined in detail.

♀. Since, at the holotype locality, further collecting has shown that two species occur together (as detailed later), it has been impossible to select an allotype female of *M. reducta*. The males of the second species are on the average considerably larger than those of *M. reducta*, and when the head-breadths of a series of females, collected with males of both species in this locality, were graphed against frequency of occurrence, the curve showed two peaks and a trough (frequency not zero) between. It is probable that the smallest of these females belong to

M. reducta. The details of this series (including both species) are as follows: *Colour*: Head very dark brown, eyes black. Thoracic and abdominal tergites dark brown, pronotum with pale golden-brown pattern (cf. Davis, 1936*a*, fig. 42; this pattern recurs frequently in the Order), other tergites with golden-brown mid-dorsal line and lateral spots. Pleurites dark brown. Sternites ranging from pale brown at centre to dark brown at lateral margins, ninth abdominal sternite dark brown throughout. Segments of antennae, legs and cerci golden-brown, paler near joints. Intersegmental membranes (not much visible) cream. *Dimensions*: Length 8·6–14·6 mm.; head, length 1·63–2·11 mm., breadth 1·22–1·73 mm.; length of apparently complete antennae 2·0–2·4 times the corresponding head-breadth, with 16–20 segments.



Figs. 1-4.—*Metoligotoma reducta* Davis.—1. Dorsal aspect of well-developed head-capsule, ♂, × 12; 2. Dorsal aspect of ♂ terminalia, × 25; 3. Ventral aspect of left cercus-basipodite, ♂, stippling to indicate degree of chitinization, adjacent structures indicated in outline to show relations, × 25; 4. Process of left hemitergite of tenth abdominal segment viewed from above, with extremity raised to same level as base, × 30.

(9. Ninth abdominal tergite; 10L, 10R, left and right hemitergites of tenth abdominal segment; 10LP, process of 10L; $10RP_1$, $10RP_2$, posterior and dorsal processes of 10R; RC_1, RC_2, first and second segments of right cercus; LC, one-segmented left cercus, dotted lines to indicate paler area between first and second segments of previous instar, now fused; H, hypandrium; HP_1, HP_2, right and left appendages of H; LCB, left cercus-basipodite. All setae omitted.)

Figs. 5-8.—*Metoligotoma illawarrae illawarrae*, n. sp. et subsp., corresponding structures, magnifications and lettering to figs. 1-4.

Figs. 9-12.—*Metoligotoma illawarrae septentrionis*, n. subsp., corresponding structures, magnifications and lettering to figs. 1-4.

Figs. 13-14.—Intermediates between *M. illawarrae illawarrae* and *M. illawarrae septentrionis*, from Jooriland, Burragorang Valley; ♂ left cercus, × 25.

One of the smallest of this series was selected as probably representing the female of *M. reducta*, and placed in the Macleay Museum, labelled accordingly. The allotype and paratype females named in the former paper were from Jooriland, Burragorang Valley, and are referable to another species, as detailed later.

Distribution of Types: The holotype male, from Elanora, near Narrabeen (16.9.34, M. Day and D. Waterhouse), is in the Macleay Museum. To those of the Museums listed (Davis, 1936*a*, p. 250) to whom male specimens were sent, as paratype material, which now prove to be referable to other species, I have forwarded correctly identified males (metatypes–topotypes) of *M. reducta*. This material has been collected at the holotype locality, being either from one of the series from this locality previously listed (Part i, p. 250) or collected more recently (24.10.37); in each case, comparison has been made with the holotype. As detailed above, there is no valid female allotype for this species.

Other Localities.—In addition to those from the holotype locality (Map 1, 1A), specimens have been examined from the following localities, the males of which appear to be exactly similar to the holotype in structure and colour: Mosman, 4.9.37, A. C. Simpson (Map 1, 1B), 9 ♂, 12 ♀; Sydney University Grounds, 25.11.36, Miss I. Bennett (Map 1, 1C), 1 ♂; Kurrajong Heights, 2.10.37, D. Waterhouse (Map 1, 1D), 1 ♂; Lindfield, 26.2.24, Dr. A. J. Nicholson (Map 1, 1E), 1 ♂; Hardy's Bay, Broken Bay, 3.10.37, Miss E. Pope (Map 1, 1F), 1♂ (also 2 ♀ not definitely referable to this species, for the same reason as at the type locality); Otford, 27.9.37 (Map 1, 1G), 3 ♂, 3 ♀.

The size limits for the males of this species included in all the series examined are within those for the type series, except the maximum length (up to 12·3 mm.). The limits for females definitely referable to this species are: Length 10·6–13·1 mm.; head, length 1·66–1·79 mm., breadth 1·28–1·38 mm. In all localities, the natural habitat is amongst dead leaves, frequently of Myrtaceous plants, lying in a mat on the ground.

Specimens from each of the above additional localities have been placed in the Macleay Museum.

Metoligotoma illawarrae illawarrae, n. sp. et subsp. Figs. 5–8.

This name is erected for specimens from Austinmer classed in Part i as *M. reducta reducta*, including the females described on p. 250, lines 9–12. Further material, gathered in the same place and structurally identical, has been included in the type series; the holotype ♂ and allotype ♀ are from the more recently collected material.

♂. *Length*: 7·2–11·3 mm.; head, length 1·44–2·21 mm., breadth 1·15–1·89 mm.; length of apparently complete antennae 2·2 to 3·4 times the corresponding head-breadth, with 17–21 segments. *Colour*: Head dark brown, almost black; eyes black. Thoracic tergites very dark brown, abdominal tergites dark golden-brown. Pleurites dark brown, sternites dark golden-brown, prosternum and hypandrium particularly dark. Segments of antennae and legs dark golden-brown, of cerci pale golden-brown, paler near joints. Intersegmental membranes (little visible) cream. *Head* (fig. 5): The head-capsule differs in outline from that of the male of *M. reducta* in that the sides run back practically straight from the eyes to the posterior angles, without any protuberance. The eyes are slightly more prominent. *Terminalia* (figs. 6, 7, 8): Right hemitergite (10R) produced backwards and downwards to a somewhat irregularly-tapered process ($10RP_1$); dorsal process of 10R ($10RP_2$) more irregular than in *M. reducta*, produced from the left-hand (free) end

of its posterior border to a tapered projection; the left-hand (free) end of its anterior border less membraneous than the rest, and produced to a thick, tapered process. Left hemitergite (10L) produced backwards from its inner margin to a slender, tapered process (10LP). Left cercus (LC) with the outer side, as seen from above, rounded, more or less semicircular in outline; inner side, distally, almost straight, minutely toothed, and flattened dorsoventrally. Basad to this straight face, which occupies almost half the length of the cercus, is a marked concavity on the inner side. Left cercus-basipodite (LCB) a small sclerite situated in the membrane between the appendages of the hypandrium and the base of the left cercus; LCB thin, heavily chitinized, ending distally in a small spine. Segments of right cercus (RC_1, RC_2), hypandrium (H) and its appendages (HP_1, HP_2) as in *M. reducta*. Thirty-nine ♂ from the holotype locality examined in detail.

♀. *Length*: 7·7–14·0 mm.; head, length 1·33–2·21 mm., breadth 1·06–1·82 mm.; length of apparently complete antennae, 1·9 to 2·2 times the corresponding head-breadth, with 17–19 segments. *Colour*: Head golden-brown with dark brown tracery (rarely dark brown throughout), eyes black. Thoracic and abdominal tergites dark brown, pronotum with golden-brown pattern, abdominal tergites with mid-dorsal line and lateral spots slightly paler than ground colour. Pleurites dark brown. Prosternum and ninth abdominal sternite dark brown, other sternites ranging from pale brown at centre to dark brown at lateral margins. Segments of antennae, legs and cerci golden-brown, paler near joints. Intersegmental membranes (usually a fair amount visible) cream. Forty-seven ♀ examined, taken with the males of the type series.

Distribution of Types: Holotype ♂, allotype ♀, and paratype ♂, in the Macleay Museum. Paratype males and females forwarded to the British Museum, the Leyden Museum, and the Western Australian Museum.

Note.—In addition to the material mentioned in Pt. i, p. 250, the type series consists of material collected in the same locality (Map 1, 2A) on 10.8.37, 12.9.37 and 20.9.37.

Other Localities: Material from the following localities is inseparable from the type series in structure or colour: Five Islands, innermost island, near Red Pt., 31.5.37 (Map 1, 2B), 11 ♂, 6 ♀; second island, 18–19.8.37, D. Waterhouse and the author (Map 1, 2C), 11 ♂, 16 ♀; Bamarang, 28.11.36, Mrs. G. L. Davis (Map 1, 2D), 2 ♂; Huskisson, 7.9.37 (Map 1, 2E), 8 ♂, 7 ♀; Parma Ck., nr. Nowra, north side, 6.9.37 and 2.10.37 (Map 1, 2F), 18 ♂. (Also 7 ♀, not definitely referable to this species, as another species was collected in the same locality.); Parma Ck., south side, 8.10.37, Mrs. G. L. Davis (Map 1, 2G), 6 ♂, 4 ♀; Hardy's Bay, Broken Bay, 3.10.37, Miss E. Pope (Map 1, 2H), 3 ♂; Red Pt., Port Kembla, 17.12.37, D. Waterhouse (Map 1, 2J), 1 ♂, 1 ♀; Jooriland, Upper Burragorang, 1.12.37 (Map 1, 2K), for details see page 232.

Size limits for all series examined: ♂, length 7·2–11·9 mm.; head, length 1·25–2·24 mm., breadth 1·06–1·92 mm. ♀, length 7·7–14·0 mm.; head, length 1·28–2·21 mm., breadth 0·99–1·82 mm.

Note.—The normal situation is as for *M. reducta*, but the specimens from the innermost of the Five Islands were amongst the creeping stems of the succulent *Mesembryanthemum aequilaterale*.

Specimens from each of the above localities have been placed in the Macleay Museum.

METOLIGOTOMA ILLAWARRAE SEPTENTRIONIS, n. subsp. Figs. 9–12.

Males collected at Elanora, near Narrabeen, 24.10.37, in association with *M. reducta*, resemble *M. illawarrae illawarrae* in most characters, but constant small differences in the terminalia necessitate the recognition of a separate subspecies. Thirteen ♂ of this series have been examined in detail.

Terminalia (figs. 10, 11, 12): The distal part of the inner face of the left cercus, practically straight in *M. illawarrae illawarrae*, in this subspecies consists of a rounded tooth at the basal limit separated from the more distal portion of the cercus by a marked concavity. Other small differences are present; the process of the left hemitergite ends more sharply, and is somewhat roughened on the left-hand side; the left cercus-basipodite is slightly different in form from that of *M. illawarrae illawarrae* (cf. figs. 8 and 12). Other characters, including the colour, show no differences, except that in the fully-developed head (fig. 9) the eyes are somewhat less prominent. *Dimensions*: Length 9·1–14·1 mm.; head, length 1·92–2·78 mm., breadth 1·57–2·40 mm.; length of apparently complete antennae 2·5 to 3·1 times the corresponding head-breadth, with 18–23 segments. Maximum antennal length observed, 6·1 mm.

Distribution of Types: Holotype ♂ and paratype ♂ in the Macleay Museum; paratype males forwarded to the British Museum, the Leyden Museum, and the Western Australian Museum. I am unable to select an allotype female, but have placed one of the largest females of the series mentioned on p. 228 in the Macleay Museum, labelled accordingly.

The males of the type series of this subspecies, and the males of *M. reducta* collected on the same date, were taken within a radius of a hundred yards, and in some cases males of both types were collected within a radius of one yard. For the type locality, see Map 1, 2′A.

Other Localities: Males from the following locality are not distinguishable from the type series in structure or colour: Yellow Rock, nr. Springwood, 15.10.37 and 28.10.37 (Map 1, 2′B), 3 ♂, 3 ♀. Colour of females as for series described on p. 229, size limits as follows: Length 14·9–17·2 mm.; head, length 2·14–2·30 mm., breadth 1·73–1·82 mm. Size limits for males within those for type series, except maximum length (14·4 mm.). (Both the above, and the type series, are on the average considerably larger than any of the series of *M. illawarrae illawarrae* examined. In both localities, the situation was the same as that detailed for *M. reducta*. Identified specimens from Yellow Rock have been placed in the Macleay Museum. The locality is the same as that mentioned under *M. reducta* in Part i, Springwood, 1.10.34, D. Waterhouse.); Jooriland, Upper Burragorang, 1.12.37 (Map 1, 2′C). (This interesting series seems to represent the intergradation of *M. illawarrae illawarrae* and *M. illawarrae septentrionis*. Of the 24 ♂ examined, 9 could be classed as the former, 5 as the latter, the remaining 10 being intermediate. The left cercus forms the most reliable basis for comparison between the two subspecies. Figures 13 and 14 illustrate the left cerci of intermediate forms from this series. The dimensions of the males of this series are: Length 7·5–12·5 mm.; head, length 1·60–2·50 mm., breadth 1·38–2·11 mm. The typical members of the two subspecies in this series are inseparable on a size basis, the averages approximating to one another.)

In association with the above, 14 ♀ were collected, not assignable to subspecies. In the original description of *M. reducta reducta* (Davis, 1936*a*,) the allotype and paratype females were selected from material from this locality. In view of the above facts, these specimens now lose all status as type material.

This series has been lodged in the Macleay Museum.

METOLIGOTOMA ILLAWARRAE TELOCERA, n. subsp. Figs. 15–22.

♂. *Length* 9·9–15·0 mm.; head, length 1·89–2·88 mm., breadth 1·47–2·11 mm. Length of apparently complete antennae 2·4 to 3·2 times the corresponding head-breadth, with 20–23 segments. Maximum antennal length observed, 6·1 mm. *Colour*: Head very dark brown, eyes black. Pronotum dark brown with pale-brown pattern, other tergites dark golden-brown with paler mid-dorsal line and lateral flecking. Pleurites dark brown. Prosternum and hypandrium dark brown, other sternites pale brown at centre merging into golden-brown or dark brown at lateral margins. Segments of legs, antennae and cerci golden-brown, paler near joints. Intersegmental membranes (a fair amount visible) cream. *Head* (fig. 15): Similar in general outline to that of *M. illawarrae septentrionis*. *Terminalia* (figs. 16–22): Similar in most respects to those of the former two subspecies, the process of the left hemitergite ending more bluntly, and the posterior process of the right hemitergite ($10RP_1$) shorter and more inwardly directed. The form of the left cercus is the chief subspecific character; it approaches *M. illawarrae septentrionis* more closely than *M. illawarrae illawarrae*, but the tooth basad to the termination on the inner side is less prominent, the termination more tapered, and the distal part of the inner face less markedly flattened dorso-ventrally and relatively shorter. In figures 19–22, as well as in figure 16, is shown the extent of variation of the left cercus in specimens from the type locality. There is, especially in figures 21 and 22, an approach to the type found in *M. illawarrae septentrionis*, but all specimens examined differ from this type. Eleven ♂ examined in detail.

♀. *Length* 12·2–18·1 mm.; head, length 1·89–2·08 mm., breadth 1·50–1·63 mm. Length of apparently complete antennae 2·0 to 2·3 times the corresponding head-breadth, with 20–23 segments. *Colour*: Head golden-brown with dark-brown tracery, eyes black. Thoracic and abdominal tergites, pleurites, and segments of antennae, legs and cerci, as in the ♂. Sternites as in the male, the eighth abdominal dark except at the centre, the ninth dark throughout. Intersegmental membranes (much visible) cream. Nine ♀ examined in detail.

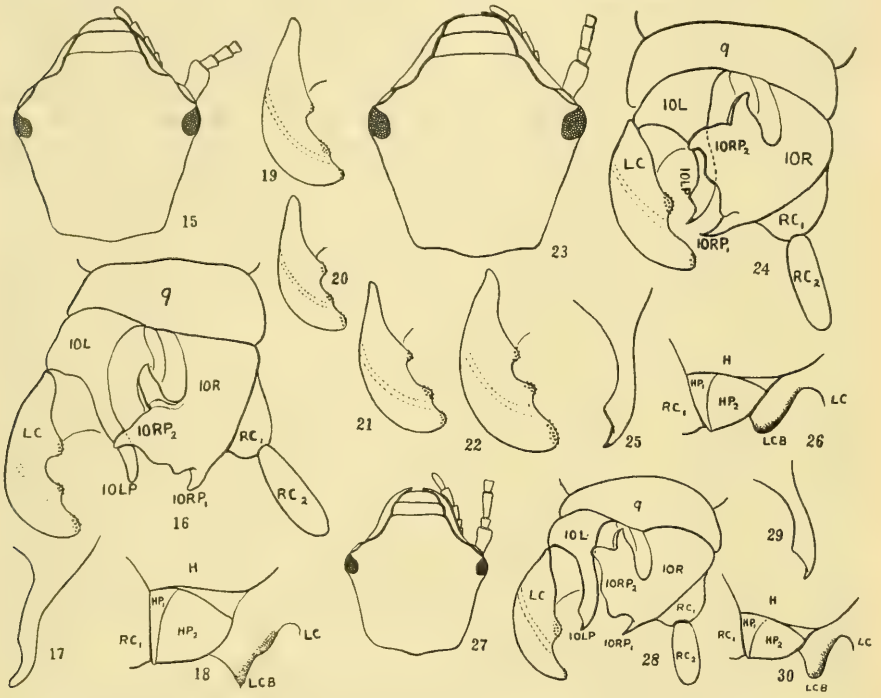
Locality: Cooper Park, Bellevue Hill (Sydney) (Map 1, 2″A), 15.9.37 and 26.9.37, amongst a mat of dead leaves of *Leptospermum*. This is practically the only locality in this district which has been left in a state sufficiently close to the original to harbour these insects.

Distribution of types: As for *M. illawarrae illawarrae*.

METOLIGOTOMA COLLINA COLLINA, n. sp. et subsp. Figs. 23–26.

♂. *Length* 9·9–13·2 mm.; head, length 2·34–2·59 mm., breadth 2·02–2·24 mm. Length of apparently complete antennae 1·6–2·0 times the corresponding head-breadth, with 17–19 segments. *Colour*: Head black, shiny, eyes black; thoracic and abdominal tergites very dark brown, pronotum with pale-brown pattern, metascutum and abdominal tergites with pale mid-dorsal line and lateral flecking. Pleurites dark brown. Sternites pale brown at centre, merging to dark brown at lateral margins, anterior abdominal sternites with greater proportion pale than the rest, hypandrium dark golden-brown throughout. Segments of antennae, legs and cerci dark golden-brown, paler near joints, paler areas on femora. Intersegmental membranes (little visible) cream. *Head* (fig. 23): Eyes not prominent. Sides of the head running back practically straight from the eyes, and converging strongly. *Terminalia* (figs. 24–26): Right cercus, hypandrium and its appendages, normal for the genus. Right hemitergite (10R) with its posterior process ($10RP_1$) slender and pointed, directed inwards and slightly curved; dorsal process of 10R ($10RP_2$) with its left-hand edge sinuate, its anterior margin with a tapered process

directed forward; left-hand part of $10RP_2$ especially membraneous. Left hemitergite (10L) with its process (10LP) directed backwards and downwards, curving to the left distally, termination tapered, acute; a flat obtuse projection is present basad to the termination, directed to the left and upwards. Left cercus (LC) curving inwards distally, with a concavity basad to the termination on the inner face, and then a rounded tooth, with minute nodules, such as are also present on the inner side of the terminal part of the cercus. Left cercus-basipodite (LCB) massive and obtuse, membraneous except distally and on the outer (left-hand) margin. Five ♂ from the holotype locality examined in detail.



Figs. 15-22.—*Metoligotoma illawarrae telocera*, n. subsp. Figs. 15-18, corresponding structures, magnifications and lettering to figs. 1-4. Figs. 19-22, variations of ♂ left cercus, × 25.

Figs. 23-26.—*Metoligotoma collina collina*, n. sp. et subsp., corresponding structures, magnifications and lettering to figs. 1-4.

Figs. 27-30.—*Metoligotoma collina exigua*, n. subsp., corresponding structures, magnifications and lettering to figs. 1-4.

♀. *Length* 10·0–12·3 mm.; head, length 1·63–1·95 mm., breadth 1·28–1·57 mm. Length of apparently complete antennae 1·8–2·2 times the corresponding head-breadth, with 15–18 segments. *Colour*: Head dark brown with golden-brown pattern, eyes black. Other structures as in the ♂, more of the intersegmental membranes visible, ninth abdominal sternite dark throughout, eighth dark except at the centre. Seventeen ♀ from the type locality examined.

Type Locality: Razorback, nr. Picton (Map 1, 3A), 18.9.37 and 27.9.37, amongst fallen leaves.

Distribution of Types: As for *M. illawarrae illawarrae*.

Other Localities: Specimens from the slopes of The Gib, between Mittagong and Bowral (Map 1, 3B; coll. 18.9.37 and 27.9.37) agree with the type series in structure and colour, and are of the following dimensions: ♂ (5 specimens examined in detail), length 10·0–11·6 mm.; head, length 1·86–2·27 mm., breadth 1·50–1·88 mm.; ♀ (8 specimens examined), length 11·0–13·3 mm.; head, length 1·60–2·08 mm., breadth 1·34–1·63 mm. Identified specimens of each sex from this series placed in the Macleay Museum. *Note.*—This locality is the same as that listed in Part i, p. 250, under *M. reducta reducta* (Mittagong, D. Lee, 30.7.35).

METOLIGOTOMA COLLINA EXIGUA, n. subsp. Figs. 27–30.

♂. *Length* 8·3–10·4 mm.; head, length 1·41–2·02 mm., breadth 1·18–1·60 mm. Length of apparently complete antennae 2·1–2·5 times the corresponding head-breadth, with 16–18 segments. *Colour*: As in the ♂ of *M. collina collina*, but somewhat paler throughout. *Head* (fig. 27): As in *M. collina collina*, the eyes a little more prominent, the sides converging less strongly. *Terminalia* (figs. 28–30): Similar in general form to *M. collina collina*, the basal part of the process of the left hemitergite (10LP) somewhat more contorted, curving down more sharply to form a hollow into which fits the basal part of the in-drawn left cercus; the subterminal flat expansion of 10LP not as broad as in *M. collina collina*; the terminal portion of the left cercus (LC) more slenderly tapered; and the processes of the right hemitergite slightly different in form.

Fifteen ♂ examined in detail.

♀. *Length* 10·1–11·0 mm.; head, length 1·47–1·60 mm., breadth 1·15–1·22 mm. Length of apparently complete antennae 1·9 times the corresponding head-breadth, with 15–16 segments. Both sexes noticeably smaller than *M. collina collina*, especially the head capsules. *Colour*: As in the ♀ of *M. collina collina*, but somewhat paler throughout. Four ♀ examined.

Locality: Wentworth Falls (Map 1, 3'A), 15.10.37, amongst fallen leaves.

Distribution of Types: As for *M. illawarrae illawarrae*.

METOLIGOTOMA INGENS Davis, 1936. Figs. 31–37.

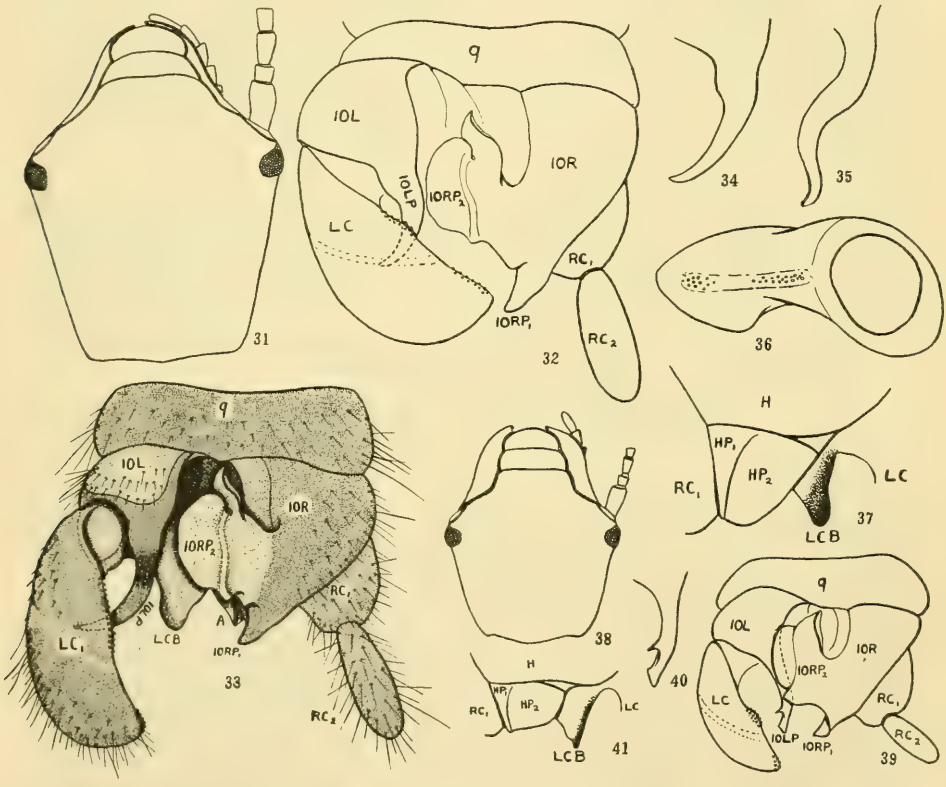
Metoligotoma reducta ingens, Davis, 1936, PROC. LINN. SOC. N.S.W., lxi (5–6), p. 250.

This species was considered previously to be structurally the same as *M. reducta reducta* of Part i; here, as elsewhere, I was impressed by the similarities between the types (which are now recognized as the marks of a compact genus) rather than their differences *inter se*, which are recognized in this paper as specific. The chief difference formerly recognized was one of size, in which further material from the type locality shows that a slight overlap may occur even within the series originally included under *M. reducta reducta*. The smallest specimens listed below in the amended description of *M. ingens* were reared in culture under somewhat unfavourable conditions, and no specimens agreeing with the lower limits have yet been found in the field; however, their occurrence under unfavourable natural conditions is possible.

The revised description is based on re-examination of available specimens of the original type-series, and on metatypes (topotypes) collected more recently from the colony from which the original series was taken. No structural variation was noticed within the complete series.

♂. *Length* 8·4–14·2 mm.; head, length 1·96–3·65 mm., breadth 1·57–2·76 mm.; length of apparently complete antennae 2·2 to 2·6 times the corresponding head-breadth, with 16–19 segments. *Colour*: See Davis, 1936*a*, pp. 250–251. *Head*

(fig. 31): Eyes not prominent; sides of the head behind the eyes straight, not converging as markedly as in the previous species. *Terminalia* (figs. 30–36): Segments of right cercus (RC_1, RC_2), hypandrium (H) and its appendages (HP_1, HP_2) normal for the genus. Right hemitergite (10R) with its posterior process ($10RP_1$) directed inwards and downwards, tapered but not acutely so. Dorsal process of 10R ($10RP_2$) with its left-hand portion membraneous, semicircular, and with a thicker anterior projection on the left-hand (free) side. Left hemitergite (10L) with its process (10LP) slender, tapered, ending sharply, greatly contorted, distally fitting into the under-side of the left cercus. Left cercus (LC) more or less semicircular in dorsal view, but in side view having a marked ventral concavity for the accommodation of the distal part of 10LP. Left cercus-basipodite (LCB) massive, obtuse, membraneous except along its distal and outer borders. Seventeen ♂ examined.



Figs. 31-37.—*Metoligotoma ingens*, n. sp. Figs. 31, 32, 34 and 37, corresponding structures, magnifications and lettering to figs. 1-4; Fig. 33, as fig. 32, stippling to show degree of chitinization, and overlap; all species are referable to the line drawings in the same way as this is comparable to fig. 32. A, inferior appendage of 10R (N.B.—Fig. 33 is freehand, not based on camera lucida outlines). Fig. 35: as fig. 34 but viewed laterally (from the left). Fig. 36, left cercus (LC of fig. 32) detached and viewed laterally (from the right); distal end to the left. × 25.

Figs. 38-41.—*Metoligotoma pentanesiana* Davis, corresponding structures, magnifications and lettering to figs. 1-4. (From the holotype).

♀. *Length* 13·6–19·2 mm.; head, length 2·13–2·67 mm., breadth 1·60–2·15 mm. Length of apparently complete antennae 1·8–2·1 times the corresponding head-breadth, with 16–19 segments. *Note.*—This species is the largest member of the family, and rivals in size the largest member of the Order (*Embia major* Imms), the maximum recorded length for which is 20·75 mm. *Colour*: See Davis, 1936*a*, p. 251. More of the intersegmental membranes visible than in the ♂.

Locality: This species is recorded only from the original locality, Black Mountain, Canberra, F.C.T. (Map 1, 4A), where it is present in large numbers.

Distribution of Types: The labels of the original types have been amended to indicate specific rank. Metatype males have been forwarded to the British Museum and the Leyden Museum.

METOLIGOTOMA PENTANESIANA Davis, 1936. Figs. 38–41.

PROC. LINN. SOC. N.S.W., lxi (5–6), pp. 254–256.

This species has been refigured from the holotype, from the same aspects as for the other species in this paper; this is especially important in figure 40, as in the earlier figure the natural downward flexure of the process of the left hemitergite obscured details of its terminal portion.

In addition to the type locality (most northerly of the Five Islands; Map 1, 5A), specimens have been secured (coll. 19.9.37, matured 12–30.10.37) at the top of the Macquarie Pass, near Robertson (Map 1, 5B). Additional measurements for the type series are: ♂, head-breadth 1·20–1·76 mm.; complete antennal length 2·5 times the corresponding head-breadth; ♀, head-breadth 1·24–1·56 mm.; complete antennal length 1·7–1·9 times the corresponding head-breadth.

The Robertson series agrees with the type series exactly in colour and structure, and falls within its size limits, with the exception of the total lengths of the largest specimens (♂, 10·0 mm.; ♀, 10·9 mm.). The series was collected amongst wood at the base of a dead stump, an unusual situation for this genus. Identified specimens of each sex from this series placed in the Macleay Museum.

This species has been taken only at the above two localities, search at adjacent places (Lighthouse Point, Wollongong; others of the Five Islands; Windang Island; localities on the Macquarie Pass) being unrewarded. It is probably a species which possessed a wider distribution formerly than at present, and has been displaced in most places by *M. illawarrae illawarrae*.

METOLIGOTOMA EXTORRIS Davis, 1936. Figs. 42–66.

PROC. LINN. SOC. N.S.W., lxi (5–6), pp. 256-257.

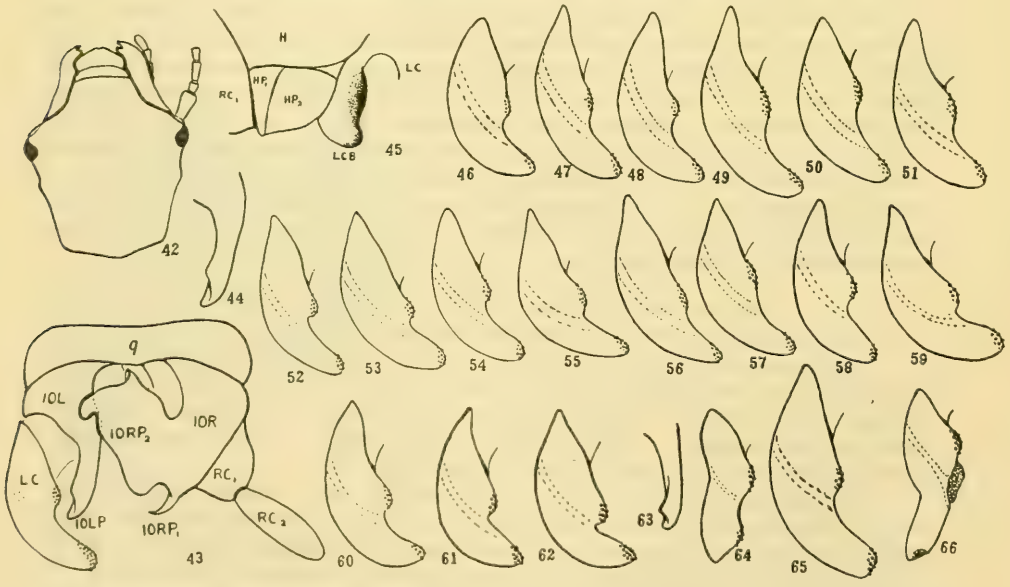
A long series (114 ♂, and a smaller number of females) obtained from the type locality (Brush Island, Map 1, 6A; coll. 5.9.37, some mature, others maturing subsequently in culture) has made possible the study of individual variation, which in this species is exceptionally marked. The revised description for specimens from the type locality is as follows:

♂. *Length* 8·6–14·1 mm.; head, length 1·60–2·77 mm., breadth 1·28–2·19 mm. Length of apparently complete antennae 1·6–2·3 times the corresponding head-breadth, with 15–21 segments. *Colour*: As in original description. *Head*: Figure 42 is a camera lucida outline of the head of the holotype ♂. *Terminalia*: A considerable amount of individual variation is seen in the left cercus, particularly in the thickness, taper and flexure of the terminal part, and in the prominence of the tooth half-way along the inner face. The range of variation in specimens from the type locality is illustrated (figs. 46–57). The other characters in the terminalia are remarkably constant, as in figures 43–45 (drawn from the holotype).

♀. *Length* 9·3–15·0 mm.; head, length 1·66–2·12 mm., breadth 1·31–1·60 mm. Length of apparently complete antennae 1·6–2·0 times the corresponding head-breadth, with 15–19 segments. *Colour*: See original description.

Distribution of Types: In addition to the types previously distributed (as listed in Part ii), a metatype ♂ (topotype) has been forwarded to the Leyden Museum. A series of males, also metatypes (topotypes), to show the range of structural variation, has been placed in the Macleay Museum.

Other Localities: Ulladulla (Map 1, 6B), —.8.37, Mrs. G. L. Davis (5 ♂), 5.9.37 (15 ♂, 15 ♀). Colour as for the respective sexes from Brush Id.; male terminalia agreeing with the Brush Id. series, but with the left cercus in general showing greater terminal curvature and more prominence of the inner tooth (figs. 58–62).—Hills west of Lake George (Map 1, 6C), coll. 3.6.37, matured 13.9.37, 5 ♂, 10 ♀. Male terminalia agreeing closely with the Ulladulla series, but with the thickening of the process of the left hemitergite more terminally placed than usual in the males from other localities (fig. 63). In one specimen, the left cercus is abnormal (fig. 64), partly retaining the larviform two-segmented nature; this is almost certainly due to injury at or before the final ecdysis.—North of Clyde River at Bateman's Bay (Map 1, 6D), coll. 4.9.37 and 5.10.37, matured 5.10.37–4.11.37, 24 ♂; also a number of females, not definitely separable from the females of another species (described below) occurring in association with them. Male terminalia as for the Brush Id. series, except that the left cercus in most cases is less slenderly tapered terminally (e.g. fig. 65). The terminal portion of the process of the left hemitergite is slightly variable.—Deep Creek, near Mogo (Map 1, 6E), coll.



Figs. 42-66.—*Metoligotoma extorris* Davis. Figs. 42-45, corresponding structures, magnifications and lettering to figs. 1-4. (From the holotype). Figs. 46-57, range of variations in the ♂ left cercus in specimens from the type locality (Brush Island), × 25. Figs. 58-62, range of variations in the ♂ left cercus in specimens from Ulladulla, × 25. Fig. 63, as fig. 44, but for Lake George specimen. Figs. 64 and 66, abnormal development of the ♂ left cercus, in individuals from Lake George and Gundary respectively, × 25. Fig. 65, usual form of ♂ left cercus for specimens from Bateman's Bay, × 25.

28.3.37, 4.9.37 and 5.10.37, matured 29.10.37 et seq., 3 ♂, 3 ♀. Male terminalia with the left cerci approaching the Ulladulla series more nearly than the Brush Id. series.—Granite Quarry, north of Moruya River (Map 1, 6E), coll. 9.10.37, matured 29.10.37 et seq., 4 ♂, 5 ♀. Male terminalia with the left cerci as in figures 48 and 57 (Brush Id. series) and figure 61 (Ulladulla series).—Gundary, nr. Moruya (Map 1, 6G), coll. 4.9.37, matured 12.10.37, 1 ♂, terminalia characteristic of this species except the left cercus (fig. 66), which is malformed in a similar way to that illustrated in figure 64.—South of Moruya River, between Moruya and Moruya Heads (Map 1, 6H), coll. 5.10.37, matured 30.10.37, 5 ♂, 8 ♀. Male terminalia with left cerci of the types illustrated in figures 51, 59 and 65; subterminal expansion of process of left hemitergite somewhat broader than usual.—South of Moruya River, nr. Moruya Heads (Map 1, 6J), 9.10.37, 13 ♂, 7 ♀. Male terminalia showing a similar range of variation to the Brush Id. series.

Representative series from each of these additional localities have been deposited in the Macleay Museum.

Size limits for all series examined: ♂, length 8·6–15·2 mm.; head, length 1·60–3·30 mm., breadth 1·28–2·50 mm.; ♀, length 9·3–16·4 mm.; head, length 1·60–2·40 mm., breadth 1·31–1·89 mm.

METOLIGOTOMA INTERMEDIA, n. sp. Figs. 67-70.

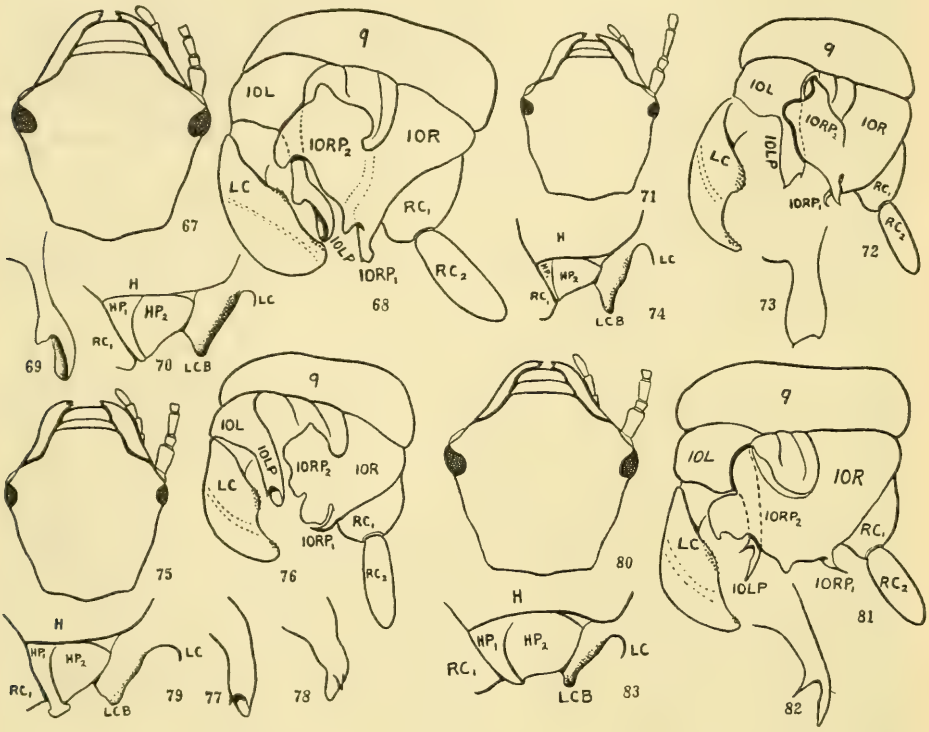
♂. *Length* 11·8–12·6 mm.; head, length 2·08–2·43 mm., breadth 1·89–2·02 mm. Length of apparently complete antennae 2·3–2·5 times the corresponding head-breadth, with 20–21 segments. *Colour*: Head very dark brown, eyes black. Thoracic and abdominal tergites dark brown, pronotum with pale brown pattern, other tergites with pale brown mid-dorsal line and lateral flecking. Pleurites dark brown. Sternites pale brown at centre merging to dark brown at lateral margins, hypandrium dark brown throughout. Segments of antennae, legs and cerci golden-brown, paler near joints, slightly paler areas on femora. Inter-segmental membranes (little visible) cream. *Head* (fig. 67) with lateral margins converging posteriorly, slightly sinuous. *Terminalia* (figs. 68–70): Segments of right cercus, hypandrium, and its appendages, normal for the genus. Right hemitergite produced backwards to a posterior process ($10RP_1$) tapering at first but expanding distally into a slight thickening. Dorsal process of right hemitergite ($10RP_2$) sub-rectangular, its three free edges contorted. Left hemitergite with a process (10LP) of very typical shape, terminating in an ovoid spoon-shaped structure, the concave side facing to the left, with a blunt process basad to this concavity directed backwards and to the left. The process and concavity accommodate the indrawn left cercus (LC), which is massive and smoothly rounded distally, the inner face having a very slight concavity and basad to it a nodulose swelling, not at all prominent. Left cercus-basipodite (LCB) subconical, membraneous except along its outer margin. Three ♂ from the type locality examined in detail.

♀. *Length* 13·3–13·9 mm.; head, length 1·89–1·98 mm., breadth 1·57–1·63 mm.; length of apparently complete antenna 1·9–2·0 times the corresponding head-breadth, with 19 segments. *Colour*: As in the male, but with golden-brown areas on the head; ninth abdominal sternite dark brown throughout, eighth markedly paler. Two ♀ from the type locality examined.

Type Locality: Tomerong, near Nowra (Map 1, 7A), 6.9.37, amongst fallen *Eucalyptus* leaves.

Distribution of types: Holotype ♂, allotype ♀ and paratype ♂ in the Macleay Museum. Paratype ♂ and ♀ forwarded to the British Museum.

Other localities: Males from the following localities agree with the type series in colour and structure: North of Parma Creek, near Nowra (Map 1, 7B), 6.9.37 and 2.10.37, 4 ♂, in association with *M. illawarrae illawarrae*. Certain females in this mixed series were obviously to be correlated with the males of *M. intermedia*, on account of their greater size, but it was impossible to separate the entire series



Figs. 67-70.—*Metoligotoma intermedia*, n. sp.; corresponding structures, magnifications and lettering to figs. 1-4.

Figs. 71-74.—*Metoligotoma anomala*, n. sp., corresponding structures, magnifications and lettering to figs. 1-4.

Figs. 75-79.—*Metoligotoma brevispina*, n. sp. Figs. 75-77, 79, corresponding structures, magnifications and lettering to figs. 1-4. Fig. 78, as fig. 77, but viewed laterally (from the left).

Figs. 80-83.—*Metoligotoma convergens*, n. sp., corresponding structures, magnifications and lettering to figs. 1-4.

of females into the respective species. Whereas only 4 ♂ of *M. intermedia* were collected, 18 ♂ of *M. illawarrae illawarrae* were taken at the same time in this locality. Males of *M. intermedia* from this series forwarded to the Western Australian Museum and the Leyden Museum.—Sassafras (Map 1, 7C), 4.10.37 and 10.10.37, 1 ♂, 3 ♀.

Males from these additional localities lodged in the Macleay Museum.

Size limits of all series examined: ♂, length 11·8–13·6 mm.; head, length 2·08–2·91 mm., breadth 1·70–2·43 mm. ♀, within limits of type series.

METOLIGOTOMA ANOMALA, n. sp. Figs. 71–74.

♂. *Length* 7·5–11·0 mm.; head, length 1·28–2·21 mm., breadth 0·96–1·82 mm. Length of apparently complete antennae 1·8–2·3 times the corresponding head-breadth, with 17–19 segments. *Colour*: Head very dark brown (almost black), eyes black. Thoracic and abdominal tergites very dark brown, golden-brown pattern on pronotum, lateral spots and discontinuous mid-dorsal line on other tergites; pleurites dark brown. Sternites ranging from golden-brown at centre to dark brown at lateral margins, prosternum and hypandrium dark throughout. Segments of legs dark brown, of antennae and cerci dark golden-brown, paler near joints. Intersegmental membranes (little visible) cream. *Head* (fig. 71): Sides sinuous, not converging as markedly as in the majority of species. *Terminalia* (figs. 72–74): This is the most divergent of all species studied in the form of the terminalia. Posterior process of right hemitergite ($10RP_1$) at first directed inwards, then curving backwards and to the right as a slender sickle-shaped process. Dorsal process of right hemitergite ($10RP_2$) giving off a tapered lobe from its posterior margin near the point of attachment to the hemitergite; this lobe, directed backwards and to the right, overlies $10RP_1$. Left hemitergite with a very distinctive subrectangular process (10LP), broad and flat, ending in two sharp points, one at the posterior limit of each side; 10LP not quite dorsoventral, the left-hand side being higher than the right. The distal edge is concave, for the accommodation of the indrawn left cercus. Left cercus (LC) very typical, crescent-shaped, with a rounded nodule-bearing lobe on the concave side midway from base to extremity. Left cercus-basipodite slender, subconical, membraneous except along the outer margin. Twenty ♂ examined.

Locality: North of Clyde River at Bateman's Bay (Map 1, 8A), coll. 4.9.37 and 5.10.37, matured 5.10.37–4.11.37; amongst moss and dead leaves.

These males were in close association with individuals of *M. extorris*. In view of their much smaller size, and the fact that the females collected at the same time fell into two size-groups with few intermediates, it is reasonably certain that the smallest of these females belong to *M. anomala*. The colour of these small females agrees with that of the males of *M. anomala* except that the head possesses paler areas.

Distribution of Types: Holotype ♂ and paratype ♂ in the Macleay Museum; paratype males forwarded to the British Museum, the Leyden Museum and the Western Australian Museum. One of the smallest females deposited in the Macleay Museum, but not recognized as allotype.

METOLIGOTOMA BREVISPINA, n. sp. Figs. 75–79.

♂. *Length* 8·0–11·0 mm.; head, length 1·60–2·24 mm., breadth 1·28–1·82 mm. Length of apparently complete antennae 1·8–2·4 times the corresponding head-breadth, with 16–20 segments. *Colour*: Head very dark brown, eyes black. Thoracic and abdominal tergites very dark brown, the latter with a tendency to golden-brown lateral spots and discontinuous mid-dorsal line. Pleurites dark brown. Prosternum and hypandrium very dark brown, other sternites ranging from pale brown at centre to dark brown at lateral margins. Segments of antennae, legs and cerci dark brown, paler near joints. Intersegmental membranes (little visible) cream. *Head* (fig. 75) with the sides converging slightly posteriorly, and slightly sinuous. *Terminalia* (figs. 76–79): Right cercus and hypandrium normal for the genus; right-hand process of hypandrium (HP_1) unusual in that, instead of tapering terminally, it expands to a small free spathulate tip. Posterior process of right hemitergite ($10RP_1$) slenderly falciform, curving inwards as in

M. extorris. Dorsal process of right hemitergite ($10RP_2$) projecting forwards and to the left, and giving off a posterior lobe near its attachment to the hemitergite. Left hemitergite (10L) small, its process (10LP) rather broad, ending in a rounded and flattened tip and bearing subterminally a short dorsal spine directed backwards and slightly to the left (figs. 77–78). Left cercus-basipodite (LCB) subconical, almost entirely membraneous. Fourteen ♂ from the type locality examined.

♀. *Length* 9·0–13·3 mm.; head, length 1·38–1·86 mm., breadth 1·06–1·44 mm. Length of apparently complete antennae 1·8–2·0 times the corresponding head-breadth, with 15–17 segments. *Colour*: As in the ♂, but the head and pronotum with paler golden-brown areas; the sternites a little paler (the ninth abdominal dark brown); the segments of antennae, legs and cerci dark golden-brown, paler near joints; and more intersegmental membrane visible. Twenty-three ♀ from the type locality examined.

Type Locality: South Bermagui (Map 1, 9A), 3.9.37 and 7.10.37, some mature, others maturing up to 4.11.37; collected amongst dead leaves.

Distribution of Types: As for *M. illawarrae illawarrae*.

Other Localities: Specimens from the following localities agree with the type series in structure and colour: Montague Island (Map 1, 9B), 3.9.37, 13 ♂, 17 ♀; south of Wagonga River at Narooma (Map 1, 9C), 6.10.37, 6 ♂, 5 ♀; north of Wagonga River at Narooma (Map 1, 9D), 6.10.37, 7 ♂, 5 ♀; slopes of the Little Dromedary, Central Tilba (Map 1, 9E), 6.10.37, 2 ♂. As another species (described later) was taken in the same situation, the females from this last locality could not be determined specifically. Identified specimens from each of these additional localities deposited in the Macleay Museum.

Size limits for all series examined: ♂, length 8·0–11·9 mm.; head, length 1·60–2·50 mm., breadth 1·28–2·08 mm. ♀, as for the type series, except maximum length (13·4 mm.).

METOLIGOTOMA CONVERGENS, n. sp. Figs. 80–83.

♂. *Length* 11·5 mm. (unique); head, length 2·40 mm.; breadth 1·82 mm. Number of antennal segments, 20; antennal length 2·1 times the head-breadth. *Colour*: Head very dark brown with golden-brown areas, eyes black. Tergites of thorax and abdomen dark brown, pronotum with golden-brown pattern, other tergites with pale lateral flecking and mid-dorsal line. Pleurites dark brown. Sternites merging from cream at centre to dark brown at lateral margins, hypandrium and prosternum dark throughout. Segments of antennae, legs and cerci golden-brown, paler near joints, the femora with paler areas. Intersegmental membranes (little visible) cream. *Head* (fig. 80): Sides converging very markedly posteriorly. *Terminalia* (figs. 81–83): Right cercus, hypandrium and its appendages normal. Posterior process of right hemitergite ($10RP_1$) a slender spine directed to the right. Dorsal process of right hemitergite ($10RP_2$) directed forwards and to the left, its free edges crenulate. Left hemitergite with a very typical process (10LP), slender and tapered, with a prominent spine, directed to the left, arising a little past midway between the origin of the process and its extremity. This process is convergent to its homologue in *M. pentanesiana*, but differs in that the portion distad to the spine is longer and thinner. Left cercus (LC) with its extremity smoothly tapered and slightly incurved; a slight nodule-bearing swelling occurs midway along the inner margin of the cercus. Left cercus-basipodite papillose in shape and fairly heavily chitinized.

♀. *Length* 12·6 mm. (unique); head, length 1·76 mm.; breadth 1·41 mm. Number of antennal segments 18; antennal length 2·0 times the head-breadth.

Colour: As in the ♀ of the preceding species, but paler throughout, and with a considerable amount of pale, cream-coloured membrane visible between all sclerites of the body.

Locality: Tilba Tilba (Map 1, 10A), 30.3.37. A single example of each sex was collected in a nest of web in the bark of a Eucalypt some four feet from the ground, a unique situation for this genus.

Distribution of Types: Holotype ♂ and allotype ♀ in the Macleay Museum.

METOLIGOTOMA BIDENS, n. sp. Figs. 84–89.

♂. *Length* 9·2–12·5 mm.; head, length 1·73–2·56 mm., breadth 1·34–2·05 mm. Length of apparently complete antennae 1·9–2·4 times the corresponding head-breadth, with 19–20 segments. *Colour*: Dorsally very dark brown with golden-brown areas on head and pronotum, and lateral flecking and mid-dorsal line on metascutum and abdominal tergites; eyes black. Pleurites dark brown. Sternites golden-brown, merging to dark brown at lateral margins, hypandrium dark brown throughout. Segments of antennae, legs and cerci golden-brown, paler near joints. Intersegmental membranes (little visible) cream. *Head* (fig. 84): Eyes relatively small; sides of the head almost straight behind the eyes, and converging less markedly than in most species. *Terminalia* (figs. 85–88): Right cercus normal; hypandrium with its right-hand process (HP_1) produced farther backwards than in other species, the tapered extremity flexed upwards. Posterior process of right hemitergite ($10RP_1$) tapered, directed backwards. Dorsal process of right hemitergite ($10RP_2$) with an extra posterior lobe near the point of attachment, directed towards the left. Left hemitergite with its process (10LP) flattened, expanding slightly terminally, ending in two spines separated by a concavity which forms the distal edge of the process. Left cercus-basipodite (LCB) subconical, outer margin sinuous and chitinized, remainder membraneous. Seven ♂ examined in detail.

♀. *Length* 9·9–13·6 mm.; head, length 1·79–2·21 mm., breadth 1·44–1·70 mm. Length of apparently complete antennae 1·7–2·0 times the corresponding head-breadth, with 19 segments. *Colour*: Head golden-brown with dark-brown tracery, eyes black, pronotum dark brown with pale-brown pattern; other tergites as in the ♂. Pleurites dark golden-brown. Sternites merging from cream at centre to golden-brown at lateral margins, ninth abdominal sternite dark brown throughout. Segments of antennae, legs and cerci as in the ♂. Intersegmental membranes more in evidence than in the ♂. Fourteen ♀ examined.

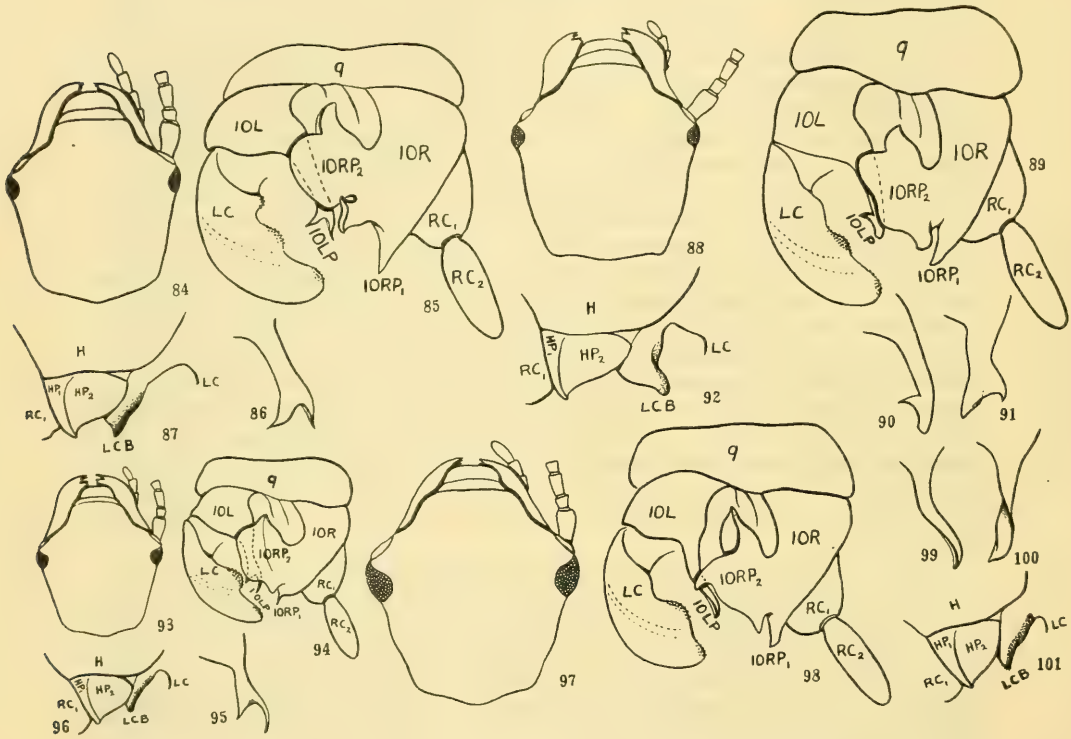
Type Locality: Mouth of Bega River, north side (Map 1, 11A), 7.10.37, amongst dead leaves.

Distribution of Types: As for *M. illawarrae illawarrae*.

METOLIGOTOMA PUGIONIFER, n. sp. Figs. 88–92.

♂. *Length* 12·6–16·5 mm.; head, length 2·40–3·04 mm., breadth 1·86–2·37 mm. Length of apparently complete antennae 2·2 times the corresponding head-breadth, with 20 segments. *Colour*: Head dark brown, eyes black; thoracic and abdominal tergites dark brown, pronotum with golden-brown pattern, metascutum and abdominal tergites with pale mid-dorsal line and golden-brown lateral flecking. Pleurites dark brown, sternites golden-brown, the anterior abdominal sternites paler medially, the hypandrium dark brown throughout. Segments of antennae, legs and cerci dark golden-brown, paler near joints. Intersegmental membranes (little visible) cream. *Head* (fig. 88) with the lateral margins behind the eyes slightly sinuous, and converging slightly posteriorly. *Terminalia* (figs. 89–92):

Posterior process of right hemitergite ($10RP_1$) tapered, directed backwards and inwards; dorsal process of right hemitergite ($10RP_2$) directed forwards and to the left, the free margins sinuous. Process of left hemitergite (10LP), as viewed from above, with a broad curved spine projecting to the left and slightly forwards, arising almost from the extremity of the process, which is obtusely tapered. Left cercus (LC) as in the preceding species but with less curvature. Left cercus-basipodite (LCB) papillose in form, largely membraneous. Five ♂ examined.



Figs. 84-87.—*Metoligotoma bidens*, n. sp., corresponding structures, magnifications and lettering to figs. 1-4.

Figs. 88-92.—*Metoligotoma pugionifer*, n. sp. Figs. 88-90, 92, corresponding structures, magnifications and lettering to figs. 1-4. Fig. 91, as fig. 90, but viewed lateroventrally (from the left).

Figs. 93-96.—*Metoligotoma minima*, n. sp., corresponding structures, magnifications and lettering to figs. 1-4.

Figs. 97-101.—*Metoligotoma begae*, n. sp. Figs. 97-99, 101, corresponding structures, magnifications and lettering to figs. 1-4. Fig. 100 as fig. 99, but viewed lateroventrally (from the left).

Type Locality: Slopes of The Little Dromedary, Central Tilba (Map 1, 12A), 6.10.37, amongst dead leaves.

As the males of this species were collected in close proximity to males of *M. brevispina*, no female types could be selected or described.

Distribution of Types: Holotype ♂ and paratype ♂ in the Macleay Museum. Paratype males forwarded to the British Museum, the Leyden Museum, and the Western Australian Museum.

METOLIGOTOMA MINIMA, n. sp. Figs. 93–96.

♂. *Length* 6·7–8·9 mm.; head, length 1·38–1·89 mm., breadth 1·06–1·50 mm. Length of apparently complete antennae 2·1–2·9 times the corresponding head-breadth, with 17–19 segments. *Colour*: Head black, shiny, eyes black; thoracic and abdominal tergites dark brown (almost black) shiny; pleurites and sternites dark golden-brown, hypandrium very dark brown. Segments of antennae, legs and cerci dark brown, paler near joints. Intersegmental membranes (very little visible) pale brown. The dark, shiny coloration of this species is exceptional amongst the related species. *Head* (fig. 93) with the sides converging behind the eyes and almost straight. *Terminalia* (figs. 94–96): Structurally close to those of *M. convergens*, of which this may actually be a subspecies. The posterior process of the right hemitergite ($10RP_1$) is directed straight back, not to the right; the dorsal process of the right hemitergite ($10RP_2$) has the free edge smoothly sinuous; the lateral spine of the process of the left hemitergite (10LP) arises from a broader base, and the portion of the process distad to the spine is more slender and acute than in *M. convergens*. The left cercus is more obtuse distally, with a more prominent lobe or tooth on the inner margin. Twenty-six ♂ from the type locality examined.

♀. Only a single ♀ (the allotype) is described; although more than 30 females were collected when the type males were secured, their close resemblance to the females of *Notoligotoma nitens* Davis, which was collected in association with *M. minima* in this district, rendered identification uncertain. The allotype was collected in a nest occupied, in addition, only by the holotype ♂. *Length*: 8·3 mm.; head, length 1·41 mm., breadth 1·09 mm. Antennae incomplete. *Colour*: Head, and tergites of thorax and abdomen, dark golden-brown, eyes black, pale mid-dorsal line in thoracic and abdominal regions. Pleurites and sternites more or less uniform golden-brown, eighth abdominal sternite dark brown at lateral margins, ninth dark brown throughout. Segments of antennae, legs and cerci dark golden-brown, paler near joints. Intersegmental membranes (a fair amount visible) cream.

Type Locality: Near Brogo (Prince's Highway, ½ mile north-east of Brogo; Map 1, 13A), 8.10.37, amongst dead leaves in crevices of rocks.

Distribution of Types: Holotype ♂, paratype ♂ and allotype ♀ in the Macleay Museum. Paratype males forwarded to the British Museum, the Leyden Museum and the Western Australian Museum.

Additional Locality: North of Dry River at Quaamaa (Map 1, 13B), 8.10.37, 11 ♂, length 7·6–10·3 mm.; head, length 1·38–2·02 mm., breadth 1·09–1·66 mm.—i.e., of larger average size than type series. Also 8 ♀, not definitely referable to the males on account of the occurrence in this locality of *Notoligotoma nitens*. Males of this series, which agrees in structure and colour with the type series, lodged in the Macleay Museum.

METOLIGOTOMA BEGAE, n. sp. Figs. 97–101.

♂. *Length* 7·6–13·1 mm.; head, length 1·34–2·72 mm., breadth 1·15–2·24 mm. Length of apparently complete antennae 2·0–2·9 times the corresponding head-breadth, with 19–20 segments. *Colour*: Head very dark brown with black tracery, eyes black. Tergites of thorax and abdomen dark brown, pronotum with pale golden-brown pattern, other tergites with pale mid-dorsal line and lateral spots. Pleurites dark brown. Sternites merging from cream at centre to dark golden-brown at lateral margins, prosternum and hypandrium dark brown throughout.

Segments of antennae and legs golden-brown, paler near joints, the femora with paler areas; cerci pale brown. Intersegmental membranes (little visible) cream. *Head* (fig. 97): Eyes prominent, sides of head behind eyes converging strongly posteriorly, with a swelling midway between the eyes and the posterior limit. *Terminalia* (figs. 98–101): Closely resembling *M. illawarrae* (especially the type subspecies). Right hemitergite (10R) and its process ($10RP_1$, $10RP_2$) with only minor differences; left cercus (LC) similar to that in *M. illawarrae illawarrae*, the concavity basad to the distal part of the inner face less markedly incised. Process of left hemitergite (10LP) simple, slender and sinuous, the termination twisted about a longitudinal axis and presenting a flattened cultriform appearance in lateral view. Left cercus-basipodite subconical, not, as in all the subspecies of *M. illawarrae*, produced terminally to a spine, but with a series of short, stout setae in a terminal position, all of approximately equal size. Fifteen ♂ from the type locality examined in detail.

♀. *Length* 10·1–16·3 mm.; head, length 1·76–2·08 mm., breadth 1·41–1·66 mm. Length of apparently complete antennae 1·9–2·3 times the corresponding head-breadth, with 18–21 segments. *Colour*: Head golden-brown with dark-brown tracery, eyes black. Tergites, pleurites and sternites as in the ♂, the ninth abdominal sternite dark brown throughout. Segments of antennae, legs and cerci golden-brown, paler near joints, femora with paler areas. Intersegmental membranes (a fair amount visible) cream. Fifteen ♀ from the type locality examined.

Type Locality: Near Bega (Prince's Highway, two miles north of Bega; Map 1, 14A), 2.9.37 and 8.10.37, amongst dead leaves.

Distribution of Types: As for *M. illawarrae illawarrae*.

Other Localities: Specimens from the following localities agree with the type series in colour and structure: Tathra (Map 1, 14B), 7.10.37, 13 ♂, 21 ♀; near Brogo (Prince's Highway, one mile south of Brogo Bridge; Map 1, 14C), 8.10.37, 7 ♂, 9 ♀. Identified specimens from these localities lodged in the Macleay Museum.

Size limits for all series examined: ♂, as for type series; ♀, length 9·9–16·3 mm.; head, length 1·54–2·08 mm., breadth 1·22–1·73 mm.

Metoligotoma tasmanica tasmanica, n. sp. et subsp. Figs. 102–105.

♂. *Length* 9·0–10·9 mm.; head, length 1·47–2·08 mm., breadth 1·22–1·66 mm. Length of apparently complete antennae 1·6–3·0 times the corresponding head-breadth, with 17–19 segments. *Colour*: Head dark brown (almost black), eyes black. Thoracic and abdominal tergites very dark brown with paler pattern on pronotum, pale mid-dorsal line and lateral flecking on metascutum and abdominal tergites. Pleurites dark brown; sternites ranging from golden-brown at centre to dark brown at lateral margins, hypandrium dark brown throughout. Segments of antennae, legs and cerci dark brown, paler near joints, femora with paler areas. Intersegmental membranes (little visible) cream. *Head* (fig. 102): Sides of head converging markedly from the eyes to the posterior limit, slightly sinuous. *Terminalia* (figs. 103–105): Right hemitergite and its processes similar in general form to those of *M. illawarrae illawarrae*. Process of left hemitergite (10LP) slender and sinuous, the extremity expanded to a more or less rhomboidal plate. Left cercus (LC) greatly incurved distally, with a distal concavity on the inner face, basad to which is a rounded lobe. Left cercus-basipodite (LCB) bluntly subconical, heavily chitinized distally and along the outer side, which is sinuous. Twenty-one ♂ from the type locality examined in detail.

♀. *Length* 8·4–12·4 mm.; head, length 1·34–1·76 mm., breadth 1·18–1·38 mm. Length of apparently complete antennae 1·7–2·0 times the corresponding head-breadth, with 16–17 segments. *Colour*: As in the ♂, but somewhat paler, head dark brown, usually with golden-brown areas, ninth abdominal sternite dark brown throughout; more of the intersegmental membranes visible than in the ♂. Eleven ♀ from the type locality examined.

Type locality: Summit of Mt. Nelson, Tas., 1,100 feet (Map 2, 1A), coll. 24.1.37 and 8.2.37, some mature, others maturing up to 12.3.37. Amongst dead leaves on and between boulders.

Distribution of types: As for *M. illawarrae illawarrae*.

Other localities: Specimens from the following localities agree with the type series in structure and colour: Slopes of Mt. Nelson, Tas., 400 ft. (near type locality; Map 2, 1A), coll. 11.2.37 and 12.2.37, some mature, others maturing up to 12.3.37, 7 ♂, 12 ♀; Bellerive, Tas. (Map 2, 1B), coll. 8.2.37, maturing subsequently,

Figs. 102-105.—*Metoligotoma tasmanica tasmanica*, n. sp. et subsp., corresponding structures, magnifications and lettering to figs. 1-4.

Figs. 106-108.—*Metoligotoma tasmanica bassiana*, n. subsp., corresponding structures, magnifications and lettering to figs. 2-4.

Figs. 109-111.—*Metoligotoma tasmanica*, specimens from Emita, Flinders Id., showing characters intermediate between subspecies *tasmanica* and *bassiana*. Corresponding structures, magnifications and lettering to figs. 1-3.

Figs. 112-115.—*Metoligotoma tasmanica biloba*, n. subsp., corresponding structures, magnifications and lettering to figs. 1-4.

Figs. 116-119.—*Oligotoma approximans*, n. sp., corresponding structures, magnifications and lettering to figs. 1-4. (LC_1, LC_2, first and second segments of left cercus; RCB, right cercus-basipodite.)

Mrs. G. L. Davis, 11 ♂, 6 ♀; near Denne's Point, North Bruni Island, Tas. (Map 2, 1C), 30.1.38, 5 ♂, 5 ♀; Simpson's Bay, South Bruni Island, Tas. (Map 2, 1D), 21.1.38, 3 ♂, 2 ♀. Identified specimens from these additional localities have been deposited in the Macleay Museum.

Size limits for all series examined: ♂, length 7·7–12·5 mm.; head, length 1·47–2·75 mm., breadth 1·22–2·14 mm. ♀, length 8·4–13·0 mm.; head, length 1·34–1·95 mm., breadth 1·18–1·54 mm.

METOLIGOTOMA TASMANICA BASSIANA, n. subsp. Figs. 106–108.

♂. *Length* 8·1–10·5 mm.; head, length 1·44–1·98 mm., breadth 1·09–1·54 mm. Length of apparently complete antennae 2·1–2·9 times the corresponding head-breadth, with 15–18 segments. *Colour* as in the previous subspecies, but paler throughout. *Head* not structurally distinguishable from that of the preceding subspecies. *Terminalia* (figs. 106–108): Dorsal process of right hemitergite ($10RP_2$) of smoother outline than in the preceding subspecies; left cercus (LC) much less incurved, the distal part of the inner face only slightly concave; terminal portion of process of left hemitergite (10LP) thinner and more acute; left cercus-basipodite (LCB) less heavily chitinized. Thirteen ♂ from the type locality examined in detail.

♀. *Length* 9·0–11·1 mm.; head, length 1·47–1·73 mm., breadth 1·12–1·34 mm. Length of apparently complete antennae 1·8–2·1 times the corresponding head-breadth, with 15–18 segments. *Colour* as in the previous subspecies, but paler throughout. Eleven ♀ from the type locality examined.

Type Locality: The Gorge, Launceston, Tas. (Map 2, 1^{1}A), coll. 6.1.38, some mature, others maturing up to 19.2.38.

Distribution of types: As for *M. illawarrae illawarrae*.

Intermediate varieties: The following forms, intermediate between the two subspecies, are of particular interest: Punch Bowl, Launceston, Tas. (Map 2, 1^{11}A), V. V. Hickman, 6.9.30. A single male, with the terminal part of the process of the left hemitergite as in *M. tasmanica bassiana*, but with the left cercus, dorsal process of the right hemitergite, and left cercus-basipodite as in *M. tasmanica tasmanica*. *Dimensions*: Length 9·3 mm.; head, length 1·66 mm., breadth 1·34 mm. Also 6 ♀, colour as in the ♀ of *M. tasmanica tasmanica*, dimensions falling within limit of type series of same. This type is only very slightly aberrant from *M. tasmanica tasmanica*.—Emita, Flinders Id., Bass Strait (Map 2, 1^{111}A), 13.1.38. Two ♂, with the left cercus and the dorsal process of the right hemitergite intermediate between the forms found in *M. tasmanica tasmanica* and *M. tasmanica bassiana*, and with the process of the left hemitergite somewhat similar to that of the latter, but also reminiscent of that of *M. begae* (figs. 110–111). Head (fig. 109) relatively broader than in other members of the species. Dimensions: Length 9·5–10·9 mm.; head, length 1·79–2·14 mm., breadth 1·50–1·86 mm.—Big River, Cape Barren Id., Bass Strait (Map 2, 1^{111}B), coll. 18.1.38, matured 9.5.38, 1 ♂, similar to those from Emita but larger (length 11·8 mm.; head, length 2·24 mm., breadth 1·86 mm.).

Specimens from the following localities on Flinders Island are probably referable to the Emita specimens, but mature males have not been secured: Palana (Map 2, 1?A), 11.1.38 (forming webs in dead leaves of *Leptospermum laevigatum*, on the ground or, more frequently, in sand collected in the forks of the *Leptospermum* trees several feet above the ground); Mt. Strzelecki, at 1,500 feet (Map 2, 1?B), 7.1.38, amongst fallen leaves; and Lady Barron (Map 2, 1?C),* 9.1.38,

* One male from this locality matured in culture (14.6.38); it is similar in structure and colour to males from Emita and Cape Barren Id., agreeing with the latter in size.

amongst fallen *Leptospermum* leaves. The size of adult females and penultimate instar males from these three localities indicates that members of these colonies are considerably larger than those of the Emita colony.

METOLIGOTOMA TASMANICA BILOBA, n. subsp. Figs. 112–115.

♂. *Length* 7·6–14·4 mm.; head, length 1·41–2·30 mm., breadth 1·12–1·76 mm. Length of apparently complete antennae 1·6–2·0 times the corresponding head-breadth, with 16–18 segments. *Colour* as for *M. tasmanica bassiana*. *Head* (fig. 112) similar to the two preceding subspecies in general form. *Terminalia* (figs. 112–115): Immediately separable from the other subspecies by the bilobed form of the left cercus-basipodite (LCB). The extra lobe arises subterminally on the outer side of the main structure, and is, with the adjacent part of the main structure, heavily chitinized.

Right hemitergite and its processes as in *M. tasmanica tasmanica*; process of left hemitergite similar to that in *M. tasmanica bassiana*; left cercus somewhat as in *M. tasmanica tasmanica*, but less incurved distally, and with a more prominent lobe midway along the inner face. Fifty ♂ examined in detail.

♀. *Length* 9·1–13·9 mm.; head, length 1·40–1·70 mm., breadth 1·09–1·28 mm. Length of apparently complete antennae 1·9–2·3 times the corresponding head-breadth, with 16–17 segments. *Colour* as in the ♂. Fifty ♀ examined.

Type Locality: Recorded only from Blythe River, near Burnie, Tas. (Map 2, 1^{iv}A), coll. 6.1.37, some mature, others maturing subsequently.

Distribution of Types: As for *M. illawarrae illawarrae*.

Note: *M. tasmanica* is structurally very similar to *M. begae*, the farthest south species recorded from the mainland of Australia (extreme south of New South Wales). It is likely that corresponding forms occur in Victoria. In some respects there are greater differences between the subspecies of *M. tasmanica inter se* than between them and *M. begae*.

Undetermined Species.

Specimens of this genus from the following localities are not capable of specific determination: Mt. Tambourine, Q.: A single ♂ (dried), from the National Museum (classed under *M. reducta reducta*, Davis, 1936*a*, p. 250), while certainly referable to *Metoligotoma*, is not in good enough condition for specific determination. It does not appear to differ greatly from *M. reducta* as defined in this paper. The record is important in showing that the genus extends to South Queensland, and therefore may be expected throughout the North Coast district of New South Wales.—Myall Lakes: A single ♂ from this locality, not now in my possession, was named as a paratype of *M. reducta reducta* (Davis, 1936*a*, p. 250). The identification is uncertain, and type status must be disallowed.—Tomat Falls, near Yerranderie: Immature specimens from this locality (Davis, 1936*a*, p. 250) are referable to the genus, the species being doubtful. The locality is difficult of access, but, in view of the proximity to Jooriland, Upper Burragorang, and the similarity of situations, this material is probably referable to *M. illawarrae*. The same applies to immature specimens from Lower Burragorang, listed under *M. reducta reducta* (l.c.).—Warrandyte, Vic., G. F. Hill, date unrecorded: Two immature specimens constitute the only record for the genus from Victoria, although it would be apparent from its presence in New South Wales and Tasmania that it occurs in parts of Victoria.—Pulpit Rock, Bagdad Valley, Tas. (Map 2, 1?E), G. H. Hardy, 8.11.14: A series containing no adult males, but probably referable to *M. tasmanica tasmanica*. The earliest record for this genus, this series is

referred to by Tillyard (1926, p. 123) as 'an undescribed species' (of *Oligotoma*). I have twice visited this district (31.1.37; 4.2.38), securing no specimens of this genus, but only *Oligotoma gurneyi gurneyi*; it transpires that the name 'Pulpit Rock' is locally applied to two distinct localities, the locality examined not being that from which Hardy's material was taken.

Key to the Species and Subspecies of Metoligotoma.

The following key, admittedly artificial, serves to distinguish the known species and subspecies of the genus. The characters are for the males. Abbreviations for the structures, as used on the figures and explained under figures 2 and 4, are employed.

1. 10LP a flat subrectangular plate, the minimum breadth at least one-quarter the length; $10RP_2$ with a slenderly-tapered lobe directed backwards and to the right above $10RP_1$ ..... *anomala*, nov.
   10LP more slender, of diverse form; $10RP_2$ not as above 2
2. 10LP ending in an ovoid concave spoon-shaped structure basad to which is a rounded lobe ..... *intermedia*, nov.
   10LP not as above 3
3. 10LP bearing a spine (other than the terminal spine) 4
   10LP without a spine, except in some species the acute extremity of the main process 9
4. Extremity of 10LP flat and rounded, with a short subterminal spine arising on the dorsal side; HP_1 with a spathulate terminal expansion ..... *brevispina*, nov.
   10LP not as above; HP_1 evenly tapered 5
5. 10LP with a lateral spine arising well basad to its extremity 6
   10LP not as above 8
6. Termination of 10LP bluntly truncate ..... *pentanesiana* Davis.
   Termination of 10LP slenderly tapered 7
7. $10RP_1$ directed outwards; free edges of $10RP_2$ crenulate ..... *convergens*, nov.
   $10RP_1$ directed backwards; free edges of $10RP_2$ smooth ..... *minima*, nov.
8. 10LP ending in two sharp spines directed outwards in opposite directions ..... *bidens*, nov.
   10LP ending obtusely, with a flat subterminal lateral spine ..... *pugionifer*, nov.
9. LCB produced terminally to a sharp spine 10
   LCB not as above 12
10. Distal portion of inner face of LC only very slightly concave, and nearly half as long as whole structure ..... *illawarrae illawarrae*, nov.
    Distal part of inner face of LC shorter and more concave 11
11. Termination of LC evenly rounded ..... *illawarrae septentrionis*, nov.
    Termination of LC somewhat tapered ..... *illawarrae telocera*, nov.
12. $10RP_1$ slenderly falciform, directed inwards 13
    $10RP_1$ directed backwards or, if inwards, then short and blunt 15
13. 10LP ending acutely 14
    10LP ending obtusely ..... *extorris* Davis.
14. LC with terminal portion slenderly tapered; head-breadth (for series examined) 1·18-1·60 mm. ..... *collina exigua*, nov.
    LC with terminal portion broader; head-breadth (for series examined) 1·50-2·24 mm. (overlapping in part with former subspecies) ..... *collina collina*, nov.
15. 10LP much curved, fitting into ventral groove of LC ..... *ingens* Davis.
    10LP little curved; LC without ventral groove 16
16. $10RP_1$ very short and blunt, directed inwards ..... *reducta* Davis.
    $10RP_1$ tapered, directed backwards 17
17. Terminal portion of 10LP twisted about longitudinal axis ..... *begae*, nov.
    Terminal portion of 10LP not so twisted 18
18. LCB bilobed ..... *tasmanica biloba*, nov.
    LCB simple 19
19. Termination of 10LP cultriform; distal portion of inner face of LC only slightly concave; free edges of $10RP_2$ of smooth outline ..... *tasmanica bassiana*, nov.
    Termination of 10LP subrhomboidal; distal portion of inner face of LC very concave; free edges of $10RP_2$ crenulate ..... *tasmanica tasmanica*, nov.

Inter-relation of species of Metoligotoma.

Certain species—*M. anomala*, *M. intermedia*, *M. ingens* and possibly *M. brevispina*—appear to lie away from any close affinity, mutual or to other

groups; others may be assigned to small "blocs". Thus *M. collina* and *M. extorris* seem to be clearly related structurally, and also geographically (with an intermediate region, about Goulburn, with no records); a similar "bloc" is formed by *M. pugionifer* and *M. bidens*, and by *M. convergens* and *M. minima*. To the latter group *M. brevispina* may possibly be referred; the other species structurally akin to *M. convergens* and *M. minima* on certain characters (*M. pentanesiana*) is probably convergent, as the respective distributions weigh against close direct relationship. The structural affinities between *M. illawarrae*, *M. begae* and *M. tasmanica* are rather marked; between the region occupied by the first and second there is a considerable zone populated by other types, with no records of this "bloc", but the structural resemblance is present in too many characters to postulate convergence with assurance, especially since comparison with other species indicates that the group of characters expressing the relationship is almost certainly not linked genetically. The true perspective on the relationship between *M. begae* and *M. tasmanica* can only be obtained by examination of material from Eastern Victoria. I am unable to refer *M. reducta* to any special group, although it does not stand as far from the general type as *M. anomala*, *M. intermedia* or *M. ingens*.

Since, according to modern interpretation, the onus of determining which differences shall be considered specific, and which subspecific or of lower category, rests entirely on the specialist dealing with the group in question, it is advisable to give some reasons for the course adopted, however arbitrary the system may appear. I have been guided in several cases by the occurrence of two forms with geographic ranges different for the most part, but common for a limited area. Where, in this zone of overlap, the two forms have kept their identity and shown no trace of intergradation, I have taken their status as that of distinct species. In some cases specific status has been given without the actual discovery and study of an overlap zone. I consider that geographic races (subspecies) of one species should show a continuous gradation of structure and distribution; when this is not so, that is, when structural changes are sudden in a short spatial distance, or when forms apparently related by structure possess an anomalous distribution (e.g. *M. illawarrae* and *M. begae*), it seems that we are dealing with distinct species, which may be closely allied naturally, or may be only superficially related on account of convergence. With regard to those forms recognized as subspecies, *M. tasmanica tasmanica* and *M. tasmanica bassiana* have intermediates in structure with a more or less intermediate distribution; but the zone between the localities of *M. tasmanica bassiana* and *M. tasmanica biloba* has not yet been examined. In the case of *M. collina* and *M. collina exigua*, there are no intermediate records; actually, the type series of the former (from near Picton) shows no size overlap with the type series of the latter (from Wentworth Falls), but another series of *M. collina collina* (from near Mittagong) shows a small overlap in size with *M. collina exigua*. Mittagong, though further horizontally from Wentworth Falls than is Picton, is intermediate in altitude.

Although *M. illawarrae illawarrae* and *M. illawarrae septentrionis* have a regular distribution, the former centred to the south of the latter (Map 1, 2A–G, J; and 2′A–B resp.), and a series including both forms with intermediates is recorded in an intermediate geographic position (Map 1, 2K, 2′C), the problem is complicated by the occurrence of a typical colony of the southern subspecies (*M. illawarrae illawarrae*) to the north of the records for *M. illawarrae septentrionis* (see Map 1, 2H). The subspecific status here, and in the case of *M. illawarrae telocera*, is provisional. In fact, many of the taxonomic facts may need review when further

records are obtained, e.g., *M. minima* and *M. convergens* may be subspecies and not distinct species. The classification submitted in this paper is of a temporary nature, but, if judgment were reserved until all localities in Eastern Australia had been examined, it would be reserved indefinitely.

Individual variation in the male terminalia for conspecific members of one colony is exceptional, being observed chiefly in *M. extorris*, the only other noteworthy case being *M. illawarrae telocera*. For *M. extorris*, a number of locality records and some long series have shown that, in addition to individual variation, there is a certain structural variation from the norm for some colonies, but a full review of the facts suggests that this is not to be recognized under definite racial or varietal names. In addition, there are in this species certain colonies of larger or smaller average size, but here again the differences seem to be merely local and not racial (subspecific). The size differences are probably genotypic rather than phenotypic; it has been noted in cultures of various species that adults reared under conditions of artificial drought tend to be below the average size, but the colonies of *M. extorris* of smaller average size range in the field from moderately moist conditions (Brush Id.) to fairly dry (Ulladulla), and those of larger average size from damp (Bateman's Bay) to moderately dry (near Moruya Heads) and dry (Mogo), these conditions depending on aspect, drainage and soil type.

Questions involving the distribution of the genus *Metoligotoma* are discussed at the end of the paper.

Oligotoma Westwood, 1836.

Oligotoma approximans, n. sp. Figs. 116–119.

♂. *Length* 6·3–6·9 mm.; head, length 1·02–1·06 mm., breadth 0·90 mm.; forewing, length 5·8–7·2 mm., breadth 1·5–1·7 mm.; hindwing, length 4·8–5·9 mm., breadth 1·4–1·7 mm. Antennae up to 3·5 mm. long, with 18 segments. *Colour*: Golden-brown, the head slightly darker, eyes black; wing veins, which are similar in arrangement to those of other members of the genus, bordered with pale brown bands. *Head* (fig. 116) smoothly rounded, eyes prominent; mandibles as in *O. glauerti* Till. *Terminalia* (figs. 117–119): Right hemitergite and its processes similar to *O. gurneyi gurneyi* Frogg., with the outer process slender and smoothly tapered. Process of left hemitergite (10LP) of very characteristic form, terminally tapering to a point, slightly incurved, and with a subterminal flat acute projection directed to the left. 10LP approximates to its homologue in *Metoligotoma minima*. Right cercus as in all members of the genus *Oligotoma*; left cercus with its first segment (LC_1) clavate, produced inwards subterminally as in *O. gurneyi centralis* Davis; second segment (LC_2) normal, subcylindrical. Hypandrium (H) tapered distally, ending truncately; left cercus-basipodite (LCB) cuneiform, embedded in membrane between the hypandrium and the base of the left cercus.

♀ unknown.

Locality: Fremantle, W.A., 20–23.5.35, K. R. Norris (holotype ♂, paratype ♂). Specimens placed in the Macleay Museum.

Oligotoma gurneyi gurneyi Frogg.

It had been noted (Davis, 1936*a*, p. 241) that *O. gurneyi agilis* Frogg. from Wagga,* and *O. gurneyi hilli* Davis, from Cotter Reservoir, F.C.T., might prove to be local varieties of *O. gurneyi gurneyi* Frogg. It is evident from data detailed

* Tillyard (1926, p. 123) refers to *O. gracilis* Frogg. from Wagga, a lapsus calami for *O. agilis*.

below that both subspecies must be rejected as synonyms of *O. gurneyi gurneyi*, which therefore has a forma aptera. Hereafter, *O. gurneyi agilis* is referred to as the Wagga series, and *O. gurneyi hilli* as the Cotter series, of *O. gurneyi gurneyi*.

In the first place, a colony from Burnie, Tas. (coll. 5.1.37, matured 18.2.37 et seq.) contained winged and wingless males. Similar occurrences were noted in colonies from near Launceston, Tas. (coll. 21.1.37, matured 23.2.37 et seq.) and Pulpit Rock, Bagdad Valley, Tas. (4.2.38). These males had terminalia identical with *O. gurneyi gurneyi* from the mainland (including the Cotter and Wagga series). A colony from Blythe, near Burnie, Tas. (coll. 3.1.37, matured 1.3.37 et seq.) appeared to have all the males wingless; while a colony from Hobart (coll. 27.1.37, matured subsequently) appeared to have all the males winged.

Although the Cotter and Wagga series showed no signs of overlap *inter se* as regards total length, a wingless male from Burnie was 9·1 mm. long, intermediate between the Cotter (maximum 8·7 mm.) and Wagga (minimum 9·7 mm.) series. In this example the ratio of head-length to maximum breadth was 10·0:7·9; the average calculated for the Cotter series was 10·0:6·9, and for the Wagga series 10·0:8·6. This ratio must be regarded as variable, in Tasmanian examples extending from 10·0:7·7 to 10·0:8·6 for winged males, and from 10·0:7·6 to 10·0:8·1 for wingless males. The total lengths of other wingless males from Tasmania lay within the limits given for the Cotter series.

It is clear that the presence or absence of wings cannot be used in this species as a systematic (subspecific) criterion. Moreover, winged males from the Australian mainland cover almost the complete size range for the Cotter and Wagga series, including the zone intermediate between these series. Although on a frequency graph for total length for the Cotter and Wagga series there are two well-marked peaks and, for the numerous specimens examined, an intermediate zone of zero frequency;* and although such a graph would normally justify the retention of the distinction as geographic races, nevertheless the occurrence of intermediates outside, and not between, the Cotter and Wagga localities (wingless intermediates in Tasmania, and winged forms intermediate in length in various New South Wales and Victorian localities) makes it necessary to abandon the subspecific names *agilis* Frogg. and *hilli* Davis. The allotype ♂ of *O. gurneyi agilis* and the holotype ♂ of *O. gurneyi hilli*, in the Macleay Museum, are named morphotypes of the forma aptera of *O. gurneyi gurneyi*.

Although no taxonomic status can be allowed for the Cotter series on the above facts, specimens of this type (of small size, males apterous, maturing mostly about May and June, colonies amongst lichen on rocks) appear to form something of a unit in this district; closely comparable colonies have been observed nearby at Lake George (coll. 3.6.37) and on high land nearer the coast and to the south (Mt. Imlay, nr. Eden, at 2,800 feet, coll. 29.3.37, matured subsequently). No colonies of other types are known from this area.

The colour of the winged males taken in Tasmania was, after some time from the last ecdysis, the same as that of wingless males taken with them and on the mainland, the sclerites being dark red-brown instead of golden-brown, the head dark brown throughout, and the wing-veins bordered with broad, dark brown bands. This is regarded as the mature colour, the paler forms described before (Davis, 1936*a*, p. 231) probably being not fully darkened after ecdysis. Certain measurements of the Tasmanian examples are given herewith as extending the size limits

* A frequency graph of the more reliable head-capsule length measurement for the Cotter and Wagga series would also give two marked peaks, but the intermediate zone would not have a frequency of zero.

previously given: Winged ♂, head-length 1·12 mm.; forewing 6·2 × 1·5 mm.; hindwing 5·1 × 1·5 mm. Female, total length 7·4 mm. All these measurements are below the previous minima for the subspecies, but other winged males, and females, from Tasmania, lay within the previous limits. In general it may be said that the colder localities appear to give individuals of smaller size.

The phenomenon of dimorphic males has been recorded for *Anisembia texana* (Mel.) (Melander, 1902, 1903), *Oligotoma japonica* Okajima (Okajima, 1926) and *Notoligotoma nitens* Davis (Davis, 1936*a*). The occurrence of colonies in which all the males are winged, or all wingless, as noted in *O. gurneyi*, and also in a few cases in *N. nitens*, suggests that the presence or absence of wings in these species is caused by a simple genetic factor (sex-limited), pure colonies deriving from a single male or several of the same form, and mixed colonies deriving from a mixed stock. It is worthy of note that, with one exception, all colonies with winged males of *O. gurneyi gurneyi* from the mainland have been in trees or fences, while the wingless forms (from Cotter Reservoir, Lake George, Wagga and Mt. Imlay) have been ground-living forms. Two of the mixed colonies from Tasmania were from the bark of trees, one (Bagdad Valley) from lichen on rocks; the pure wingless colony from Blythe, Tas., was from lichen on rocky ground, and the pure winged colony from Hobart, Tas., was chiefly in a decayed fence, but also extended to the rocky face of a quarry.

The wingless ♂ from Lady Julia Percy Id., Vic. (Davis, 1936*a*, p. 239) can now be regarded as a forma aptera of the Lucindale and Adelaide (S.A.) specimens described in the same place, but whether this series is to be referred to a separate subspecies, or to *O. gurneyi gurneyi* × *O. gurneyi centralis*, must remain undecided until further collecting has been carried out in this region. Males from Chinchilla, Q. (—.5.35, per A. P. Dodd), another point in the zone intermediate between those of the above subspecies, but in a different sector from Lucindale and Adelaide, are exactly similar to *O. gurneyi gurneyi*, except in the outer process of the right hemitergite ($10RP_1$), which is as in *O. gurneyi centralis*. The Lucindale–Adelaide specimens differ from *O. gurneyi gurneyi* chiefly in having the left cercus-basipodite as in *O. gurneyi centralis*.

The recognition of a forma aptera of *O. gurneyi gurneyi* renders more probable the identification as *O. gurneyi gurneyi* of the series from Pyrmont (Froggatt, 1905; Friederichs, 1923; see also Davis, 1936*a*, p. 237, note).

Additional localities for *O. gurneyi gurneyi*, in the Furneaux Group, Bass Strait, indicate the means of entry of this subspecies into Tasmania (as discussed later). The following localities are recorded: The Bluff, nr. Whitemark, Flinders Id., 6.1.38; East Sister Id., 12.1.38; West Sister Id., 11.1.38 (the two latter islands are immediately to the north of Flinders Island).

Oligotoma latreillei (Rambur).

Previously I had seen no females of this species from Australia, but recently I obtained a series from the British Museum, including a number of mature females together with a few males (coll. F. H. Taylor, 14–15.12.27, Townsville, Q.). These agree in colour and form with the females from Noumea previously examined, and are of the following dimensions: Length 7·7–9·7 mm.; head, length 1·12–1·44 mm., breadth 0·91–1·16 mm.; maximum observed number of antennal segments 22; antennal length up to 2·2 times the head-breadth. Sixteen ♀ examined. Specimens in the Macleay Museum.

Notoligotoma Davis.

Notoligotoma nitens Davis, 1936.

The following additional localities for this species are recorded: Razorback, nr. Picton, 27.9.37 (locality of 3A, Map 1); East Kangaloon, nr. Robertson, 27.9.37 (near locality of 5B, Map 1); Jooriland, Upper Burragorang, 1.12.37 (locality of 2K, Map 1); Quaamaa, 8.10.37 (locality of 3B, Map 1). At the first, third and fourth of these localities, this species was living in association with the corresponding species of *Metoligotoma*, that is, in similar situations and separated by not more than several inches from the colonies of the other genus.

These records extend the range of the species somewhat to the west, and a considerable distance to the south. Close examination of specimens from these localities, and those previously listed (Davis, 1936*a*, p. 248) show that there is no variation throughout the recorded range, so that in this case no error has been introduced by the nomination of type material from a number of different localities. In the same way, no error seems to have resulted from designating as allotype of *N. hardyi* (Fried.) a female from Nyngan, N.S.W. (Davis, 1936*a*, p. 246), although Friederich's type males were from Perth, W.A.; the males from Western Australia and New South Wales, and also from Townsville, Q., are structurally indistinguishable.

Discussion.

Distribution.

The genus *Metoligotoma* appears to be ideal for the study of the distribution of its species with a view to tracing their natural ranges, and attempting to correlate them with causes such as geographic barriers, past and present. Both sexes are wingless and fairly sedentary. The males possess distinct systematic characters which, while having little individual variation, show marked changes from one district to another. The genus is fairly widespread, ranging at least from South Queensland to Tasmania. It is a specialized and apparently recent type. Finally, there is the consideration that its members are easily kept in culture in the laboratory, thus offering the possibility of producing hybrids under controlled conditions.

In spite of this, the results obtained from a study of the distribution of the species of *Metoligotoma* have been disappointing from the point of view of correlation with barriers or other patent causes, and no reasons can at present be advanced for specific distribution. However, certain negative results have been obtained, showing that certain apparent barriers fail to divide the genus specifically, and that such facts as altitude and geological formation are ineffectual as causes (selective or otherwise) of specific differentiation or localization in this genus.

With regard to differences in elevation of the localities of any one species, *M. pentanesiana* is found near sea-level on the Five Islands and at a height of about 2,600 feet near Robertson; *M. tasmanica tasmanica* occurs near sea-level at Bellerive, Tas., and at 1,100 feet on Mt. Nelson, Tas. Other species show a similar, if less marked, altitudinal distribution. With regard to the range of rock types on which any one species may occur, *M. reducta* occurs on Hawkesbury sandstone at Narrabeen, and on Narrabeen Shale near Otford; *M. illawarrae illawarrae* occurs on Hawkesbury sandstone at Hardy's Bay, on rocks of the Upper Coal Measures at Austinmer and of the Upper Marine Series at Huskisson, and also on igneous rock (Dapto dolerite on the two innermost of the Five Islands, and granodiorite at Burragorang). With regard to climatic changes as indicated by latitude and distance from the coast, as well as by elevation, the genus is divided into a number

of species on the New South Wales coast from north to south, and similar changes may occur proceeding from the coast inland, as in the cases of *M. collina* and *M. ingens*. This distribution might possibly be correlated with changes in temperature and humidity, but, considering all the facts, I am disinclined to believe that climate is limiting in specific distribution in this genus; at all events, three species may occur in the same locality, as at Tilba Tilba, all exposed to the same climatic conditions; and the distribution of *M. extorris* from the coast to Lake George, at least 60 miles from the sea, together with those cases of altitudinal distribution cited above, shows that one species may endure a wider range of climatic variation than that which is sometimes embraced by the entire range of two or more adjacent species. Also, all species appear to flourish in culture at Sydney.

With regard to geographic barriers, the most obvious are those which appear to be offered by large rivers and estuaries, and by expanses of sea separating coastal islands from the mainland. The nature of the genus suggests that such barriers as they exist at present would be extremely effective against migration. Collecting was therefore carried out on five coastal islands (three of the Five Islands, Brush Id., and Montague Id.) and, where possible, on both sides of the larger rivers of that part of the New South Wales coast studied. Similar collecting was carried out in Tasmania and the Furneaux Group. The discovery of *M. pentanesiana* at Robertson, and of *M. extorris* at numerous localities, on the mainland, discounts the theory put forward earlier (Davis, 1936*b*, p. 257) that these species were evolved, under the influence of isolation, on the most northerly of the Five Islands and on Brush Id. respectively. In addition, *M. brevispina* has been found on Montague Id. as well as at several mainland localities, and *M. illawarrae illawarrae* on the innermost two of the Five Islands, as well as at numerous mainland localities. *M. tasmanica tasmanica* occurs on North and South Bruni Id. as well as on the main island of Tasmania, while a form apparently intermediate between this subspecies and *M. tasmanica bassiana* (also from the main island of Tasmania) occurs on Flinders and Cape Barren Islands. Furthermore, the range of *M. illawarrae illawarrae* straddles such rivers as the Hawkesbury and Shoalhaven, and of *M. extorris* such rivers as the Clyde and Moruya; *M. brevispina* occurs on both sides of the Wagonga R. and the Bermagui R.; and *M. tasmanica tasmanica* on both sides of the River Derwent, Tas. In most of these cases the distribution argues against the crossing of the rivers having been effected by migration away from and around the wider estuarine portions.

At this stage a consideration of the recent changes of sea-level on the Australian coast is imperative. Daly (1934) allows a universal eustatic rise of sea-level of some 75 metres (41 fathoms) within the last 25,000 years, followed more recently (probably within the last 3,000 years) by a slight fall (some 5 metres). The 75 metres rise is correlated with the melting of the ice on the Würm (Wisconsin) glaciation of the northern hemisphere. There is fairly general agreement as to the applicability of these principles to the present case. It seems very probable that no true land movements, of sufficient importance to invalidate the arguments advanced below, have occurred in Australia within this period. This sequence, being eustatic, applies to all portions of the coastline.

Montague Id. is joined to the mainland of Australia by a submerged isthmus (running towards the Little Dromedary, where similar rocks occur to those on the island), the deepest point on which is 17 fathoms. In the same way, the most northerly of the Five Islands is separated from the mainland by a depth of only about 12 fathoms over the shallowest route. In the case of Brush Id., the deepest water separating it from Murramarang Pt. is about 3 fathoms; the innermost of

the Five Islands is separated from Red Point by about the same depth, and is joined to the other island on which *M. illawarrae illawarrae* occurs by a low, wave-swept isthmus. Obviously, Montague Id. and the most northerly of the Five Islands have been severed at some time during the last rise in sea-level (probably about 10,000 years ago), while Brush Id. and the two innermost of the Five Islands may have been separated near the end of the rise in sea-level, or by erosion at some subsequent period. All these islands have been habitable for the genus since severance. These facts fix a limit of some 10,000 years during which, even in apparently such a plastic genus as *Metoligotoma*, no specific change has occurred. These changes in sea-level have also affected the coastal rivers and estuaries in their effectiveness as barriers to migration. It follows that the genus *Metoligotoma* was probably occupying its present range in New South Wales, and differentiated into most, if not all, of its present species, at least half-way through the process of the last eustatic rise of sea-level.

The migration of the genus to Tasmania is explained in the same way. Tasmania is separated from Victoria by a submerged isthmus* running through the Kent and Furneaux Groups (Map 3), the deepest water along which is 32 fathoms, some of which is undoubtedly due to marine and submarine erosion at and since submergence; the tide-rips in this sector are amongst the worst on the Australian coast. The genus *Metoligotoma* is recorded from Flinders Id., Cape Barren Id. (south of Flinders Id.) and over a large area of Tasmania. Over the shallowest route, the deepest water from Flinders Id. to Cape Barren Id. is 4 fathoms, from Cape Barren Id. to Tasmania 18 fathoms. There can be no doubt that *Metoligotoma* migrated across the Bassian Isthmus (the Order is of northern derivation) during a period of low sea-level. The same applies to *Oligotoma gurneyi gurneyi*, recorded from Tasmania, Victoria and New South Wales, and from Flinders Id., and two islands north of it (East Sister Id., West Sister Id.), which are too small to possess sufficiently sheltered situations for *Metoligotoma*. Collection and study of *Metoligotoma* from Southern Victoria and the Kent Group should strengthen the above hypothesis.

The records of *M. tasmanica tasmanica* on North and South Bruni Id. throw light on the past climate of Tasmania. North and South Bruni are joined by a low isthmus of sand-dunes, and were almost certainly separate islands 3,000 years ago. The shallowest connection to the main island of Tasmania runs from the extreme south of North Bruni (Soldier's Point) and the extreme north of South Bruni Id. (Simpson's Pt.), and is at the deepest 6½ fathoms. There are also submerged ridges from the north end of North Bruni Id. (Denne's Pt.) to both the north and south side of the Derwent Estuary, each reaching 9 fathoms at the neck. While it is impossible to say by which route or routes the genus reached its present localities (Map 2, 1C, 1D), it is evident that it must have reached as far south as 43° S. latitude before the connection to Bruni Id. was severed. It must be remembered that the locality on S. Bruni Id. (Map 2, 1D), at 43° 16′ S. latitude, is the farthest southern record for the genus, which is absent from the colder and wetter parts of Tasmania (Map 2, XA–XK); the record is, with one exception (*Embia taurica* Kus. from the Crimea, 44° 20′ N. latitude: see Kusnezov, 1904), the highest latitude for the Order. These facts suggest that Tasmania has possessed a climate no more extreme than the present during the last 6,000 years. Correlations of the Tasmanian glaciations with those of the northern hemisphere, or absolute estimates of their age, are at present vague (Lewis, 1933). These

* For previous references to the Bassian Isthmus see Hedley (1903) and Tillyard (1913).

facts, together with others which biologists may from time to time adduce, may help in the estimation of these ages. It is probable, for instance, that the last (Margaret) glaciation of Tasmania pre-dated the Würm–Wisconsin glaciation, which was, according to the above interpretation, still in force when the genus *Metoligotoma* reached Bruni Id.

There is no absolute proof that the species of *Metoligotoma* did not take up their present distribution at an earlier period of low sea-level. Facts against this are (i) that the genus is specialized and apparently recent, with species whose limited distribution argues of their recency; (ii) with reference to the Tasmanian migration, it is putting the Margaret glaciation too far back to postulate the entry of *Metoligotoma* to its Tasmanian localities at an earlier low sea-level. The migration to Tasmania of *Oligotoma gurneyi gurneyi* is placed as coincident with that of *Metoligotoma*, for climatic reasons. It is unlikely that *Metoligotoma* will be found on King Island. *M. tasmanica biloba*, from the western part of the north coast of Tasmania, is by its structure derivable from the other subspecies, and probably fairly recent in origin. It seems to agree with the 'Age and Area' Principle, being structurally more advanced and geographically more limited than *M. tasmanica tasmanica*. The McCoy Society Expedition (1937–8) to King Island secured no Embioptera, although a special search was made.

The limits of the genus *Metoligotoma*, as opposed to those of each of its species, are probably in part determined by climatic factors. Situations in which the genus occurs are neither very wet nor very dry. Its apparent absence from the drier parts of New South Wales can be satisfactorily explained climatically, but certain apparently suitable situations in the more westerly parts of the Blue Mts. (Hartley, Hampton, Oberon, etc.) have been searched without success. The genus is apparently absent from this region, but no explanation can be given other than

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2H, at Hardy's Bay, Broken Bay; 2J, at Red Point, near Port Kembla; 2K, at Jooriland, Upper Burragorang.

2′.—*M. illawarrae septentrionis*, nov.: 2′A, at Elanora, near Narrabeen; 2′B, at Yellow Rock, near Springwood; 2′C, at Jooriland, Upper Burragorang (2K-2′C indicates that intermediates between 2 and 2′ also occur).

2″.—*M. illawarrae telocera*, nov.: 2″A, Cooper Park, Bellevue Hill, Sydney.

3.—*M. collina collina*, nov.: 3A, at Razorback, near Picton; 3B, at the Gib, near Mittagong.

3′.—*M. collina exigua*, nov.: 3′A, at Wentworth Falls.

4.—*M. ingens* Davis: 4A, at Black Mtn., Canberra (A.C.T.).

5.—*M. pentanesiana* Davis: 5A, on most northerly of the Five Islands; 5B, at the top of Macquarie Pass, near Robertson.

6.—*M. extorris* Davis: 6A, on Brush Id.; 6B, at Ulladulla; 6C, on hills west of Lake George; 6D, at Bateman's Bay, north of Clyde R.; 6E, at Deep Ck., near Mogo; 6F, at Granite Quarry, north of Moruya R.; 6G, at Gundary, near Moruya; 6H, south of Moruya R., between Moruya and Moruya Heads; 6J, south of Moruya R., near Moruya Heads.

7.—*M. intermedia*, nov.: 7A, at Tomerong, near Nowra; 7B, on north side of Parma Ck., near Nowra; 7C, at Sassafras.

8.—*M. anomala*, nov.: 8A, at Bateman's Bay, north of Clyde R.

9.—*M. brevispina*, nov.: 9A, at South Bermagui; 9B, on Montague Id.; 9C, at Narooma, south of Wagonga R.; 9D, at Narooma, north of Wagonga R.; 9E, on slopes of the Little Dromedary, Central Tilba.

10.—*M. convergens*, nov.: 10A, at Tilba Tilba.

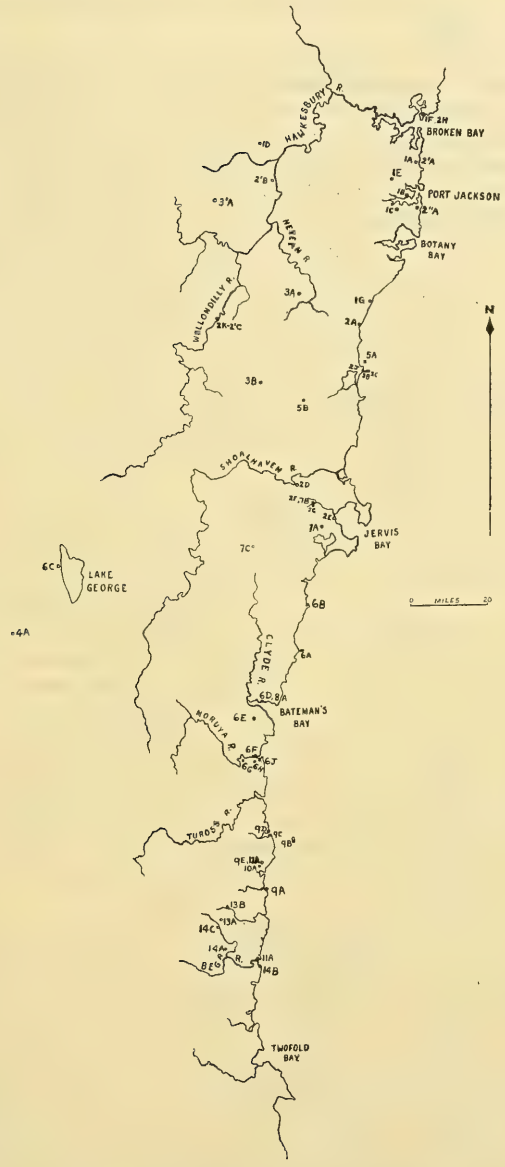
11.—*M. bidens*, nov.: 11A, north of Bega R., near mouth.

12.—*M. pugionifer*, nov.: 12A, on slopes of the Little Dromedary, Central Tilba.

13.—*M. minima*, nov.: 13A, near Brogo (½ mile north-east of Brogo); 13B, at Quaamaa, north of Dry River.

14.—*M. begae*, nov.: 14A, near Bega (2 miles north of Bega); 14B, at Tathra; 14C, near Brogo (2 miles south of Brogo Bridge).

N.B.—"A" represents type locality in each case.



Map 1.—Central and South Coastal districts and Dividing Range, New South Wales, to show distribution of species of *Metoligotoma*.

1.—*M. reducta* Davis: 1A, at Elanora, near Narrabeen; 1B, at Mosman; 1C, at Sydney University; 1D, at Kurrajong Heights; 1E, at Lindfield; 1F, at Hardy's Bay, Broken Bay; 1G, at Otford.

2.—*M. illawarrae illawarrae*, nov.: 2A, at Austinmer; 2B, on innermost of Five Islands; 2C, on second of the Five Islands; 2D, at Bamarang, near Nowra; 2E, at Huskisson; 2F, on north side of Parma Ck., near Nowra; 2G, on south side of Parma Ck.;

that it is such a recent genus that it has not yet migrated here from its point of origin (presumably coastal).

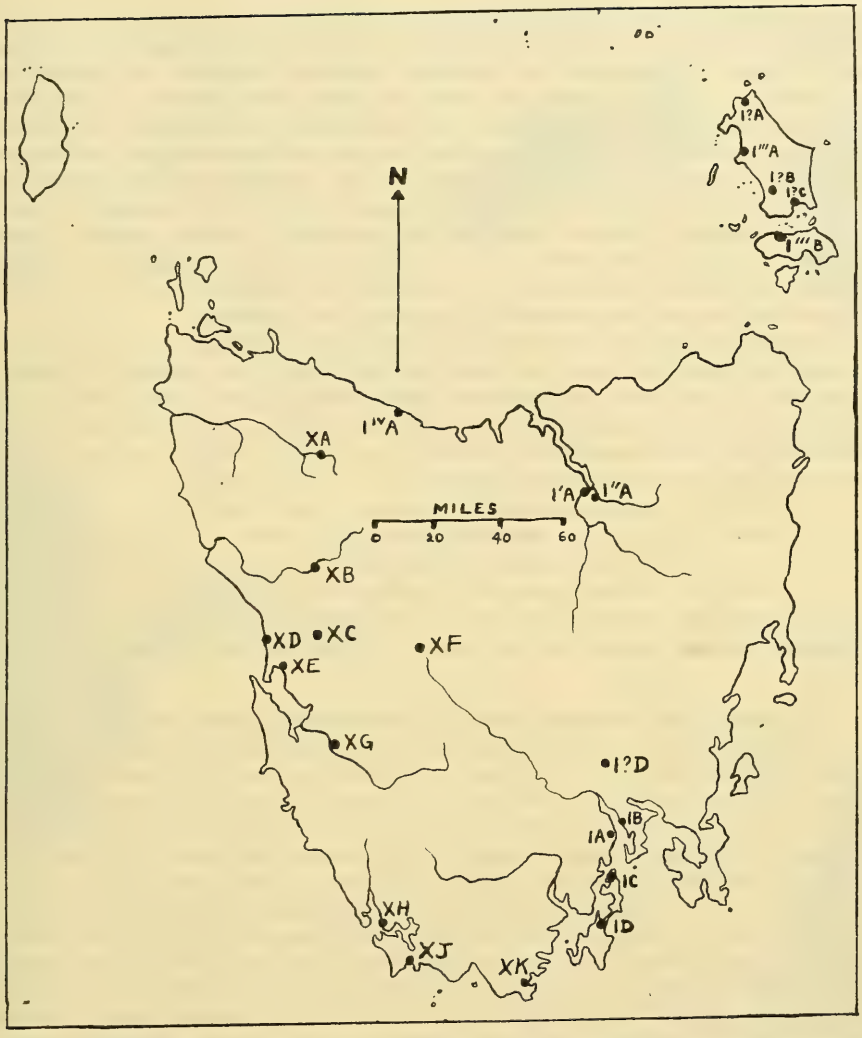
Certain districts, within the broad outline of the generic range, where there is a general tendency to swampy conditions, such as the Bulli Pass area and the mountains between Nerriga and Bateman's Bay, seem to be ecologically unsuited to such a ground-living genus, and may even act to some extent as ecological barriers. The genus is likewise absent from the belts of rain-forest along the coastal district. The centre, west coast, and extreme south of Tasmania seem to be similarly unsuited to the genus, and to the Order in general. Careful search at localities XA–XC, XF–XK of Map 2 revealed no trace of Embioptera. The high rainfall in these localities (up to 100 inches annually), combined with the cold, renders these regions unsuitable for these insects. Several of these localities are no colder than the summit of Mt. Nelson, the type locality of *M. tasmanica tasmanica*; but the rainfall at the latter place is not so high as to prevent the formation of situations congenial to this genus. At two localities on the central west coast of Tasmania (XD, XE), apparently suitable situations were found on shrub-dunes, but no Embioptera were present. Large areas of unsuitable country would act as a barrier to prevent the insects reaching these situations.

In order to trace whether the limits of the various species of *Metoligotoma* were related in any way to those of species of other genera, a list of species of the genus *Cardiothorax* (Family Tenebrionidae, Order Coleoptera) was obtained from Mr. H. J. Carter, together with the known range of each. This genus extends from Cape York to Victoria, and the remarks made concerning the suitability of *Metoligotoma* for distributional studies apply largely to it also. Its members are often found in the same situations as *Metoligotoma*. Consideration of the ranges of its species, especially *Cardiothorax castelnaudi*, *C. pygmaeus* and *C. walcknaeri*, indicates that no correlation exists with the ranges of species of *Metoligotoma*. The same applies to the ranges of species of land-shells, wherever sufficient data are available. A close correlation in the ranges of species of several genera might have indicated that a common cause, however obscure, had effected specific distribution in each genus; but in view of this lack of correlation, the details of specific distribution for the genus *Metoligotoma* (Maps 1 and 2) are submitted without explanation; the distribution seems to be the result of haphazard species-formation and haphazard migration.*

With the conclusion that geographical isolation here appears to play no explicable part in species formation and distribution, the opinion may also be given that no patent form of biological isolation, structural or temporal, appears to separate species occupying zones of overlap. In spite of the variety of the

* Of course, each specific differentiation must have resulted from some efficient cause, and the sum total of migration from the point or points of origin of each species must be the result of certain positive or negative factors. I would imply that the facts indicate that it is impossible to assign the actual cause of each differentiation, or the time of its occurrence, and that migration does not appear to have proceeded to a point where each species has its range limited by environmental factors, but rather has been governed by incidental causes which it is impossible to trace, producing a distribution which appears to be haphazard and which is almost certainly not static or final.

Davey; XJ, New Harbour; XK, Recherche Bay. Except at XD and XE, situations favourable to the genus do not occur at the above localities, the whole of the area west of the line XA-XJ probably being without members of the Order, for climatic reasons. At XD and XE restricted situations, apparently suitable, are found, but no members of the genus, probably on account of the barrier of unsuitable country between.



Map 2.—Distribution of the genus *Metoligotoma* in Tasmania and the Furneaux Group.

1.—*M. tasmanica tasmanica,* nov.: 1A, at Mt. Nelson, summit, 1,100′ (also on slopes at 400′); 1B, at Bellerive; 1C, near Denne's Pt., North Bruni Id.; 1D, at Simpson's Bay, S. Bruni Id.

1^{1}.—*M. tasmanica bassiana,* nov.: 1^{1}A, at The Gorge, Launceston.

1^{11}-1^{111}.—Types showing characters intermediate between 1 and 1^{1}: 1^{111}A, at Punch Bowl, near Launceston; 1^{1111}A, at Emita, Flinders Id.; 1^{1111}B, at Big River, Cape Barren Id.

1^{1v}.—*M. tasmanica biloba,* nov.: 1^{1v}A, at Blythe R., near Burnie.

1?.—*M.* sp. indet. (no mature males collected): 1?A, at Palana, Flinders Id.; 1?B, on slopes of Mt. Strzelecki, Flinders Id., at 1,500′; 1?C, at Lady Barron, Flinders Id.;* 1?D, at Pulpit Rock, Bagdad Valley. (A-C are probably as from Emita, Flinders Id.; D, probably as from Mt. Nelson-Bellerive.)

X.—Localities where *Metoligotoma* does not occur: XA, Hellyer Gorge; XB, Pieman R., near Rosebery; XC, Lake Margaret, near Queenstown; XD, Henty River; XE, Strahan; XF, Lake St. Clair; XG, Eagle Ck., Gordon River; XH, Roaring Beach, Port

* See footnote, p. 248.

male terminalia, whose constituents may have some functional importance during copulation, as detailed later, the identical structure of all the females of the genus sets at nought any possibility of structural biological isolation. As regards time of maturation, in practically all localities where two different species were occupying adjacent nests, the members of each species reach maturity at the same time, so that adults of both sexes of each species could be collected on the same day in the space of one yard. In one case, the admixture of *M. extorris* and *M. anomala* north of the Clyde River at Bateman's Bay, the two species seemed to mature at slightly different times, but not without a certain amount of overlapping. Since the facts, although by no means proving the existence of biological isolation in time, are of interest as supporting the difference in the two species bionomically as well as structurally, they are given in detail.

As the females of the two species are indistinguishable, and as they are much longer-lived than the males, the times of maturing of the males are listed as indicative of this point. The material was collected on 4.9.37, 5.10.37 and 9.10.37, all adults being preserved when collected, and all immature specimens cultured. The cultures were examined on 11.10.37 and 4.11.37, mature specimens being preserved. The results were as follows:

On 4.9.37: Mature males of *M. anomala*, 1, of *M. extorris* 0.
From 5 to 11.10.37: Mature males of *M. anomala* 13, of *M. extorris* 5 (2 having just undergone ecdysis).
On 4.11.37: Mature males of *M. anomala* 6, of *M. extorris* 19.

These figures, although too few to be sound statistically, suggest that a difference obtains between the two species in the time of maturation.

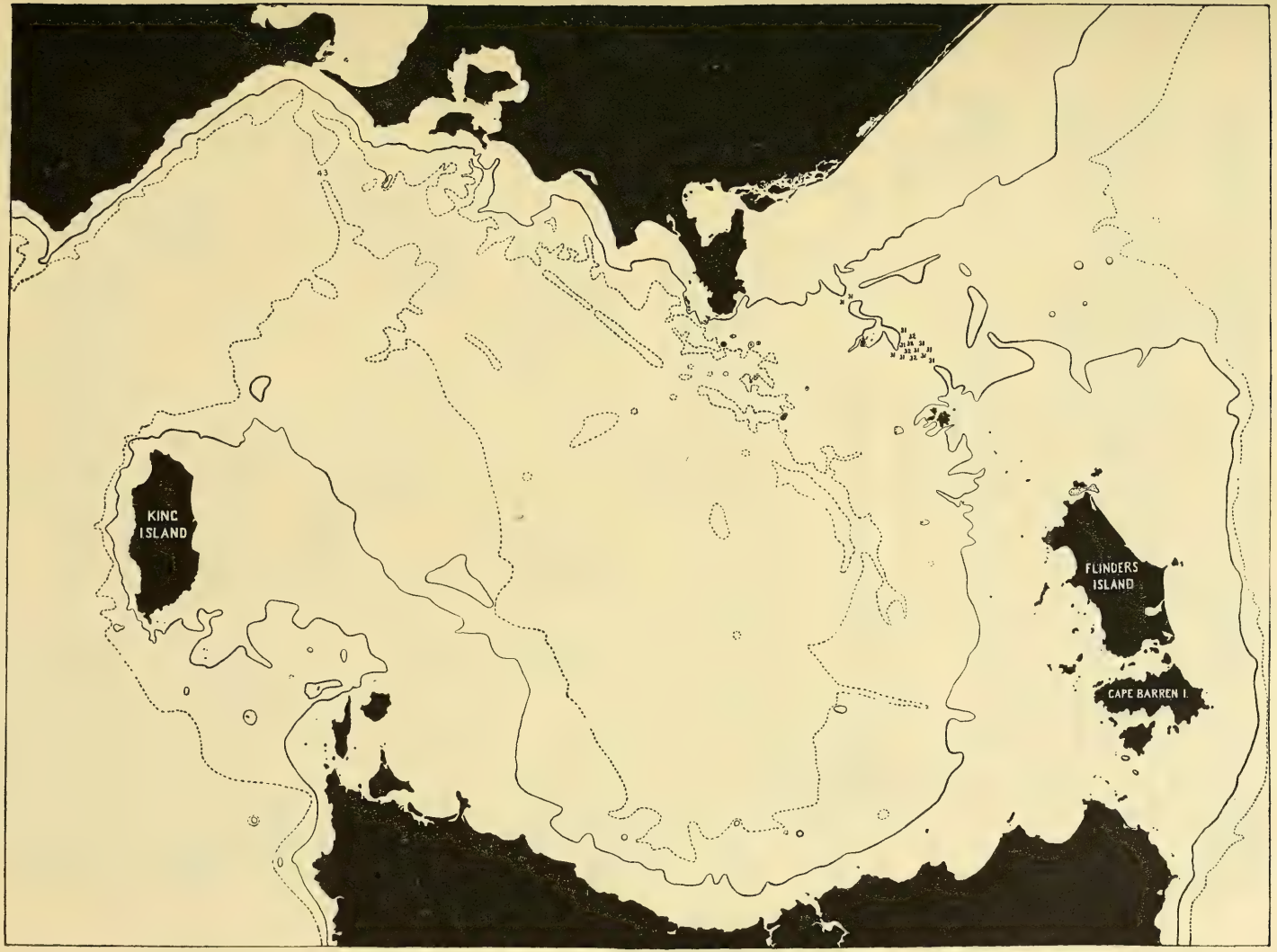
Convergence.

The Law of Corresponding Stages, as enunciated by Arber and Parkin (1907) in connection with a study of floral morphology, is (mutatis mutandis) of the utmost importance in the following study. As outlined by these authors, the principle is as follows: "If we study the stages in evolution reached by the different organs of a seed-plant at any one period, we shall find that they are dissimilar. Some are obviously more highly evolved than others. Corresponding stages in the evolution of the various members* of a seed-plant are not contemporaneous in point of time. Conversely, at any one period in geological time, one organ or set of organs will be found to have reached a far higher stage of evolution than another." Considered genetically, this principle is a statement of the fact that the factors controlling one character or set of characters may change while other factors remain stationary, and that on different lines of descent varying factors undergo changes at different times and in different sequence. Application of this principle to a study of convergence in the Order Embioptera has proved very helpful, as indeed it must in any group.

Figure 120 represents a scheme for the phylogeny of certain selected species of Embioptera. The end of each sequence represents a present-day form. Where an existing form has been placed on the direct ancestral line of another form, it is implied that the hypothetical ancestor resembled the existing form named—at least for those characters here dealt with—and that the existing type has changed little in these characters from this ancestor.

The following characters are considered from an evolutionary viewpoint: wings, first abdominal sternite, and characters of the male terminalia—left and right cerci, left and right hemitergites of the tenth abdominal segment and their

* Organs.—C.D.



Map 3.—Bass Strait, with 30- and 40-fathom isobaths (entire and broken lines respectively). Soundings in excess of 30 fathoms on the neck of the former 'Bassian Isthmus' (31, 32 fathoms) also indicated. Approximately 40 miles to the inch.

processes. These characters are illustrated in Figure 120, and below each species is given a list of the genetic factors supposedly controlling the characters, as follows:

1.—Wings: 1A* present, with both R_{4+5} and M two-branched; 1B present, with R_{4+5} two-branched, but with M reduced to one branch; 1C present, with both R_{4+5} and M reduced to one branch; 1D absent. Note: 1CD represents those cases in which there are winged (1C) and wingless (1D) forms in the same species.

2.—First abdominal sternite: 2A comparatively normal; 2B much reduced.†

3.—Tarsal bladders: 3A, less than two bladders or arolia on second segment of hind tarsi; 3B, two bladders on this segment.

4.—Left cercus: 4A, two distinct subcylindrical segments; 4B, first segment more or less clavate, second segment distinct and subcylindrical; 4C, first segment clavate, second shortened and not distinctly divided from first; 4D, two segments entirely fused.

5.—Right cercus: 5A, first segment subcylindrical, longer than broad; 5B, first segment broader than long.

6.—Process of left hemitergite of tenth abdominal segment: 6A, process simple; 6B, process with a lobe or spine arising well basad to termination; 6C, process with a terminal hook.

7.—Right hemitergite of tenth abdominal segment: 7A, more or less simple; 7B, with a long slender backwardly-directed process on the outer side; 7C, with a dorsal nodule-bearing process curving forward; 7D, with a dorsal foliaceous process. Note: (6, 7) represents a simple, undivided tenth tergite.

The supposition that one or a few factors control each phenotypic character examined, and that this can be represented by a simple symbol, is not based on any actual genetic work.

The supposed genetic change whereby each form is derived from the immediately preceding is shown on the line connecting them (e.g. 1A→1B). Except for those controlled by 2 and 3, all characters are sex-limited. The genetic constitution of the females, with regard to the remaining characters, is, as far as we can say, the same as for the corresponding males; but phenotypically they are similar to a male which would be represented by 1D, 4A, 5A, (6, 7).

In some cases, several modifications of one character have been included under one factor-symbol. The condition of the male left cercus in *Haploembia*, *Monotylota* and *Oligotoma vosseleri* (first segment only slightly clavate) and in *Oligotoma tillyardi*, *O. glauerti* and most of the Embiidae‡ (first segment very markedly clavate) are attributed to the factor symbolized by 4B.

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* This symbol has no reference here to the first anal vein.

† I am in some doubt as to the validity of this character. Enderlein (1912) gives the details for the female only, listing it in the Embiidae (s. lat., including Clothoda) as 'vorhanden', and in the Oligotomidae as 'verkümmert'. In all types which I have examined, the structure of the first abdominal sternite is identical in both sexes, and it seems likely that Enderlein and other workers have made particular reference to the female merely because this is the only family character found in this sex, the other family characters being limited to the male. In all three Australian genera of Oligotomidae the first abdominal sternite is present but reduced to a small triangular sclerite. No figures are given by Enderlein for this character, but in females of *Ptilocerembia roepkei* (Embiidae) which I have examined, the structure is certainly fairly well developed. Imms (1913), referring to *Embia major*, mentions that this sternite is small in both sexes. All the forms classed by Enderlein in the Embiidae are tentatively listed as 2A, and in the Oligotomidae as 2B. *Anisembia wheeleri* (Melander) is recognized by Chamberlin (1923) as an Oligotomid, though classed by Enderlein as an Embiid (*Haploembia wheeleri*); it is probable that this species has the sternite reduced (2B).

‡ I follow Tillyard (1937) in recognizing the Clothodidae as a distinct family, and use the term Embiidae in the strict sense. Enderlein (1912) recognizes the Clothodinae as a subfamily only, within the family Embiidae.

Only seven characters have been selected for consideration, to prevent excessive complexity; it will be realized that other characters, such as the left cercus-basipodite and the hypandrium, should also be taken into account. For instance, consideration of hypandrium structure would separate *Oligotoma saundersi* Westwood from the 'primitive species of *Oligotoma*' of figure 120, with which *O. saundersi* agrees for the set of characters enumerated here; and the specialization of the hypandrium characteristic of *Metoligotoma* would further differentiate that genus from other types, being capable of interpolation at about the times of the changes 1C–1D, 4C–4D, 5A–5B and 7A–7D.

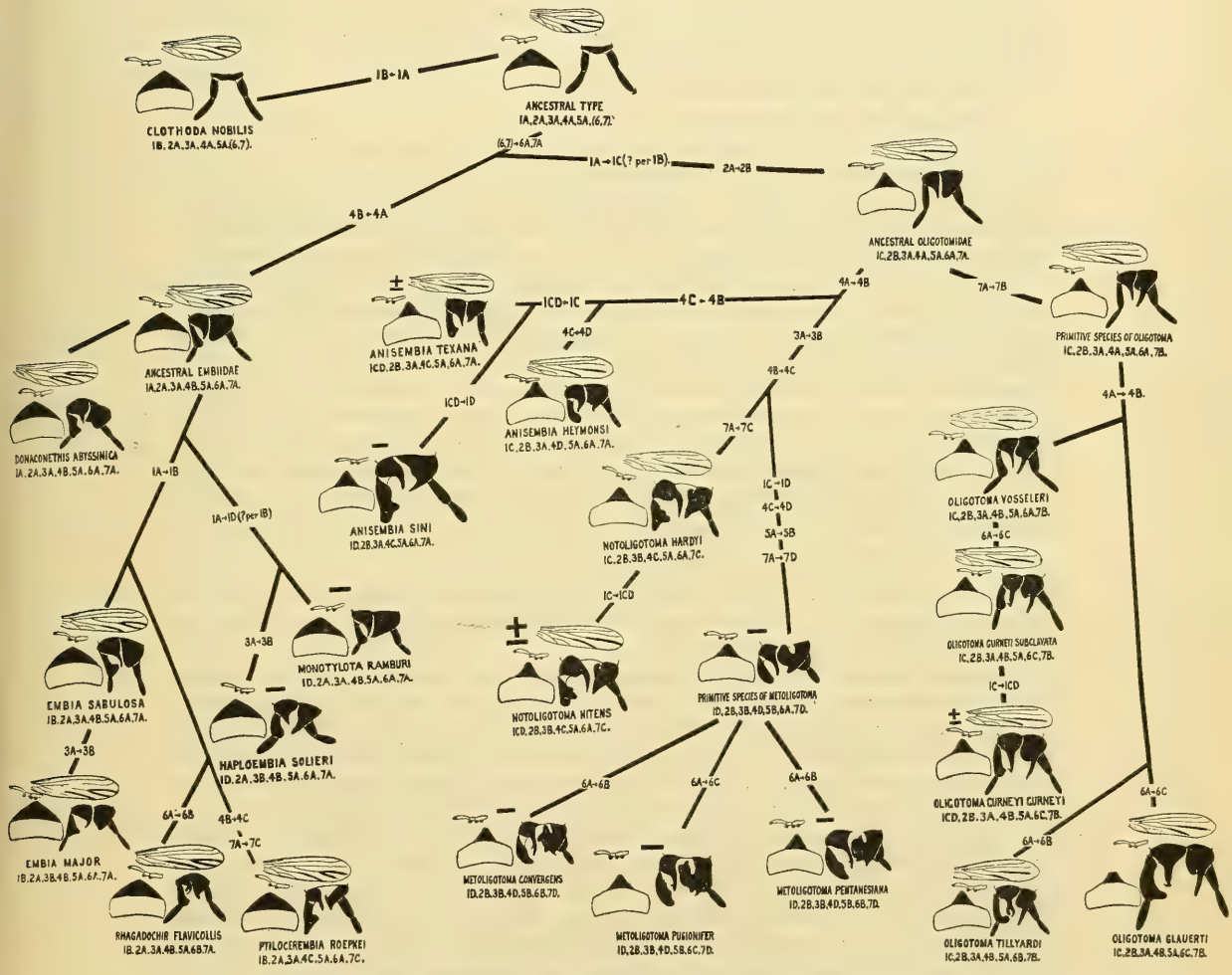

Fig. 120.—Phylogenetic scheme for certain selected species of Embioptera, with the assumed genetic constitution of each species listed for seven characters, which are illustrated for each species. Changes by which each species is derived from the preceding indicated on line joining ancestor and descendant. Diagrams not to scale; lengths of connecting lines for convenience in spacing only, not proportional to divergence in structure or time. For detailed explanation see text.

The scheme has been drawn up in the simplest possible way; convergence has not been invoked unless the opposite course does violence to any known facts. Whether the simplest scheme is necessarily correct depends on one's opinions on the frequency of convergence; this is discussed later.

Phylogenetic sequence.

1.—1A gives rise to 1B; 1C is derived from 1A, probably through 1B; 1D is derivable from 1A, 1B, or 1C; 1CD represents a stage where some individuals have undergone the change 1C–1D, others remained at 1C.

2.—2A gives rise to 2B.

3.—3A gives rise to 3B.

4.—4A gives rise to 4B, which in turn gives rise to 4C. 4D is derivable from 4B through a stage resembling 4C.

5.—5A gives rise to 5B.

6.—6A can give rise either to 6B or to 6C.

7.—7A gives rise to 7B, 7C or 7D.

It is unlikely that 6B and 6C, or 7B, 7C and 7D are mutually derivable. (6, 7) represents the ancestral condition of 6A, 7A.

These sequences have been strictly followed in figure 120. In general, A represents an ancestral stage, and B a derived one; but the alphabetical sequence does not represent a linear series, e.g. 7C, 7D do not have any lineal relationship.

The above sequences are reached by a study of comparative morphology, and also, in the case of the changes in the left cercus and the original derivation of other types from (6, 7), by a study of ontogeny. With regard to wing-venation, Tillyard (1937) describes a fossil from the Permian of Kansas (*Protembia permiana*) which he considers, with reason, to be a true Embiopteron; this form has an even more complete venation than that here symbolized by 1A. The cerci of *Protembia* were apparently symmetrical and of more than two segments, and the male tenth tergite symmetrical and entire. For the characters examined in figure 120, *Protembia* would be more primitive than the stages governed by 1A, 4A and 5A, and otherwise probably would be represented by 2A, 3A, (6, 7).*

Detailed consideration of the Phylogenetic Scheme.

If winglessness on the *Monotylota–Haploembia* line has been derived through the stage controlled by 1B, it would be simpler to separate this line below the change 1A–1B on the *Embia*-line.

The distribution of *Notoligotoma* and *Anisembia* suggests that the change 4B–4C is convergent in these two genera, and that they are not derived from a common ancestor possessing the factor 4C. *Anisembia* is a North American genus, *Notoligotoma* Australian, the latter being probably derived from ancestors from the Indo–Malayan region. A common descent from a form possessing the factor 4C (e.g. of the constitution 1C, 2B, 3A, 4C, 5A, 6A, 7A) is, while simpler in that it postulates one less case of convergence, actually unlikely; it is difficult to conceive any locality for the ancestor of genetic constitution (1C, 2B, 3A, 4C, 5A, 6A, 7A) that conforms to all the facts of distribution. In a like way, the distribution of *Metoligotoma pentanesiana* and *M. convergens* (Map 1) weighs against the common descent from a form possessing the character controlled by 6B, for, even granting a somewhat wider past distribution for *M. pentanesiana* than at present, there would be a considerable intermediate zone populated by forms represented for this character by the factor 6A.

* Zalessky (1937) has meagrely described a similar type (*Tillyardembia biarmica*) from the Upper Permian of Russia.

Oligotoma vosseleri has been placed away from the direct line to *O. glauerti* and *O. tillyardi*, and on the ancestry of *O. gurneyi*, on account of its mandible structure (see Davis, 1936*a*, p. 233), which, as in *O. gurneyi*, is more specialized than in *O. glauerti* and *O. tillyardi*.

Embia major differs from it congeners in the presence of an extra tarsal bladder (fide Imms, 1913, p. 173). In those cases where no mention of tarsal bladders has been made by Enderlein (1912)—e.g. *Rhagadochir*—it is assumed that the normal state obtains, two being exceptional, and as such certain to be mentioned.

Tillyard (1937, p. 249) states that the cerci are asymmetrical in all recent genera except *Clothoda*. The fact that such species as *Oligotoma saundersi* and *O. latreillei* possess on each side two subcylindrical segments, practically, if not entirely, symmetrical, proves that the asymmetry of the tenth abdominal tergite predated the asymmetry of the cerci. This course has been followed in the scheme.

The scheme, which has been prepared without prejudice as to the naturalness or otherwise of existing systems of classification, supports the general principles laid down by Enderlein (1912)* and modified by Tillyard (1937). The separation of *Clothoda* is marked, and it does not appear to be on the direct line to the Embiidae, s. str. The dichotomy to Embiidae and Oligotomidae, following division of the tenth abdominal tergite, appears to be based on very important characters (1C and 2B appear to be monophyletic† for the Oligotomidae). At the same time, such a scheme illustrates the artificiality of most specific keys; for instance, in the key to the species of *Metoligotoma* in this paper, the presence of a character whose factor is referable to 6B places species in a group which is almost certainly not natural.

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* With the exception of the species now referred to *Anisembia*; see Chamberlin (1923).

† In this connection it may be mentioned that *Notoligotoma* shows a very great resemblance to *Ptiloceremb*ia on the male terminalia, both on the characters of the left cercus, left and right hemitergites and processes, and also on the unlisted characters of the 'ventral process' (identical with left cercus-basipodite) and the trapezoidal plate basally separating the left and right hemitergites. The form of the right hemitergite of *Ptiloceremb*ia has been included under 7C, though Friederichs (1923) makes no mention of nodules on the forwardly-directed process, such as are found in *Notoligotoma* (although not mentioned by Friederichs in his description of *Oligotoma hardyi* (= *N. hardyi*) either). I consider from Friederichs' figure (fig. 7) and description (Links (Cercus) 1. Glied hinten wulstförmig verdickt, nach innen verlängert und daselbst gezähnt. Das 2. Glied ist kurz und plump an das 1. angesetzt. Der linke Cercus ist kürzer als der rechte) that the left cercus is rightly referable to '4C', especially since he has greatly exaggerated the length and distinctness of the second segment of the left cercus of *Notoligotoma hardyi* in his figure (l.c., fig. 1; cf., however, Davis, 1936*a*, fig. 8). Since *Notoligotoma* is probably derived from an Indo-Malayan ancestor, it seems possible that *Ptiloceremb*ia (from Sumatra) may be near its ancestral line; this would necessitate some modification of figure 120, separating *Notoligotoma* (and probably *Metoligotoma*) further from *Anisembia* and other Oligotomidae, and deriving them from *Ptiloceremb*ia by a change of 1B-1C (*Ptiloceremb*ia to *Notoligotoma*) convergent with that in the true Oligotomid stock. Whether the change 2A-2B would also be interpolated between *Ptiloceremb*ia and *Notoligotoma* is uncertain, as the validity of this character is doubtful (see above). This view would make the family Oligotomidae (as recognized by the criterion '1C') polyphyletic, but would render unnecessary the convergence of 4B-4C, 7A-7C, postulated in figure 120 for *Ptiloceremb*ia and *Notoligotoma*. With reference to the polyphyly of the family Oligotomidae (as recognized by 1C) demanded by this course, it is to be noted that the venation of *Notoligotoma*, though similar in disposition, is more strongly developed, that is, less obsolescent, than in *Oligotoma*; this supports the view that *Notoligotoma* is derived, not from a form near *Oligotoma*, but by an independent loss of R_5 as present in the Embiidae.

Consideration of convergence in characters dealt with in figure 120.

1.—Convergence by loss is of greater frequency than convergence by acquisition. Loss of the second branch of M is convergent in the development of *Clothoda* from the ancestral type and in the development of the *Embia*-line from primitive Embiidae, and, if 1C is derived from 1A by way of 1B, on the Oligotomid line also. Loss of wings in some (1CD) or all (1D) individuals of a species is convergent in the *Monotylota–Haploembia* line, *Anisembia texana* and *A. wheeleri*, *Notoligotoma nitens*, *Oligotoma gurneyi gurneyi*, and the line leading to *Metoligotoma*.

2.—Apparently no convergence.

3.—Development of an extra tarsal bladder is convergent in *Embia major*, *Haploembia*, and the line leading to *Notoligotoma* and *Metoligotoma*.

4.—The change 4A–4B occurs in the development of primitive Embiidae, the development of the *Anisembia–Notoligotoma–Metoligotoma* line from primitive Oligotomidae, and the development of the majority of species of *Oligotoma* from the primitive species of this genus.

The change 4B–4C* occurs convergently in *Ptilocerembia* (not very completely) and in *Notoligotoma* and *Anisembia*, probably separately in the latter. The development of 4D is convergent in *Anisembia heymonsi* (End.) and the genus *Metoligotoma*.

5.—The change 5A–5B appears to be monophyletic.

6.—The type of factor classed as 6B arose convergently from 6A in *Rhagadochir*, *Oligotoma tillyardi* and *Metoligotoma pentanesiana* (see Davis, 1936*b*, p. 257), and probably separately in *M. convergens* (see above).

The type of structure classified as 6C arose convergently in *Oligotoma glauerti* (somewhat modified), *O. gurneyi* and *Metoligotoma pugionifer*. The change 7A–7C appears to be convergent in *Ptilocerembia* and *Notoligotoma*.† The change 7A–7B appears to be monophyletic, emphasizing the naturalness of *Oligotoma*, s. str., as defined in Part i (p. 231). The change 7A–7D appears to be monophyletic, as with 5A–5B; this, together with such additional characters as the hypandrium, emphasizes the naturalness of the genus *Metoligotoma*.

Convergence and Determinism.

Below is advanced a deterministic theory of convergence of homologous structures,‡ involving the Law of Corresponding Stages, which seems to explain naturally even such outstanding cases of convergence as the fore limbs, etc., of Mantidae and Mantispidae, members of different major groups of Pterygota.

Whatever cause one assigns to evolutionary changes—whether it be mutation, orthogenesis, somatic induction, non-adaptive variation due to chemical or physical stimuli in the environment—most workers will agree that every genotypic change has some cause, however obscure, and that, if similar causes act on similar genetic organizations under similar conditions, similar effects will be produced, which

* According to figure 120; but see footnote on page 267.

† According to fig. 120; but see footnote on p. 267.

‡ Convergence of homologous structures may appear a contradiction in terms to those who reserve the term 'homologue' for a structure necessarily present in the common ancestor of types compared. The use of 'homologous' in this paper implies, not common descent from a type posessing the structure, but a closer correspondence than would be conveyed by the term 'analogous'; the correspondence is so close that it is assumed that a similar genetic constitution is responsible for the 'homologues'. The term 'convergence' in this paper is applied to the phenomenon classed by Osborn (1905) as parallelism, not convergence.

will be manifested by similar characters. This argument can be applied to the gene or genes controlling a certain character, no matter what stages have been reached in the evolutionary sequence by the genes controlling other characters.

Considering the factor (or factors) represented by 6A in figure 120, similar causes should produce the same changes, and, except for the possibility of modifying effects of other genes, develop the same characters, no matter what be the constitution of the genes controlling the other characters considered. Thus the character represented by 6B arises convergently in association with quite different combinations of other characters in *Rhagadochir*, *Oligotoma tillyardi* and *Metoligotoma pentanesiana*, merely by the normal working of efficient causation. This argument can be applied to all cases of convergence of homologous structures.

An objection to the above may be put thus: 'Why are not the characters represented by, say, 6B, absolutely similar in all three types?' This does not seem to damage the validity of the theory in general, since it is probable that (1) the change 6A–6B may not be in one step; not all the required steps may have been taken in the same direction in each case, only the causes for certain of the steps having recurred in all cases: the variety of structures included under 6A itself (as under 4B, 7A, etc.) is met by this consideration; (2) there may have been the same cause and effect (or sequence of causes and effects) for the gene primarily concerned with the character 6 in each case, but modifying factors affecting the character 6 may be present on other factors, possibly on some of the factors listed (1, 2, 3, 4, 5, 7); or (3) environmental differences might cause slight phenotypic differences in the various types possessing the identical factor 6B. (3) does not apply to the Embioptera, but must be taken into consideration in some groups. With reference to this objection, however, the closer the convergence, and the more surprising it may otherwise appear, the more directly is it explained by the present theory. In the case of recurrence of identical non-atavistic colour-patterns in different families or genera of Rhopalocera, which may or may not have a functional significance mimetically, the same consideration holds; and the closer the types, the greater the likelihood of identical effects being produced, since less possibility has occurred for the primary factor in the two types to undergo any steps in divergent directions, in the short time since the dichotomy of the two types, before the common cause for the convergent change came into play; and less possibility has been present for the development of divergent modifying factors.

It may be said now that the true phylogeny of the types studied may actually be anything between that given in figure 120 and a scheme in which the end-type of each line would be placed at the distal end of a separate radius, the centre of these radii representing a common ancestor which might not even possess the ordinal characters of the Embioptera. This latter seems to be an extreme view, but some intermediate probably obtains.

In general, convergence of characters of some functional use is likely to be noticed more frequently than that of purposeless or harmful characters, not because it would occur more frequently, but because it would be more likely to be selected and preserved. Convergence by loss is more likely to occur than convergence by acquisition, since the causes of loss of a gene or the rendering of it non-functional appear more likely to recur frequently than causes adding to the complexity of the genetic constitution. These two views are supported by actual observation in numerous groups of animals and plants.

The present theory allows of the prediction of the structure of species which may be discovered in future. Actually, the species *Oligotoma approximans*, the specimens of which were received after the theory was fully developed, combines

characters of the right hemitergite of *O. gurneyi gurneyi*, the left cercus of *O. gurneyi centralis*, the mandibles of *O. glauerti*, the hypandrium and left cercus-basipodite similar to *O. tillyardi*, the left hemitergite of *Metoligotoma minima*, and wings, legs, first abdominal sternite, etc., as in all species of *Oligotoma*.

The theory advanced is also applicable to a consideration of whether any species is derived from a single individual which underwent the change differentiating it from its immediately ancestral species, or whether this change occurred independently in a number of individuals. The independent development of the new specific character in different individuals would correspond to cases of convergence. On the arguments applied to figure 120, it seems not unlikely that the character would be independently derived on more than one occasion. This view is supported by the recurrence of certain mutations in *Drosophila*.

Structure and Function.

Although variations in structure of the terminalia of the genus *Metoligotoma*, and indeed of the Order in general, often appear at first sight to be orthogenetic in origin, closer examination frequently reveals a functional use for certain organs, although in annecent species slightly different modifications may perform the same purpose apparently with equal efficiency. When the mode of copulation is considered (cf. Friederichs, 1934, figs. 9, 10), the necessity for efficient copulatory appendages is realized, and any added efficiency in this direction seems likely to possess a very definite survival value. The mode of copulation also explains the asymmetry of the male terminalia.

In species of *Metoligotoma* with a lateral spine on the process of the left hemitergite, the angle between this spine and the main process serves as a guide to the left cercus, which, when adpressed to this angle, forms an efficient clasping organ. This function was overlooked previously (Davis, 1936*b*, p. 257). The same function appears to be served in *Rhagadochir*, but here the 'ventral process'* and not the left cercus fits into the angle. The nodules frequently found on the inner side of the left cercus (e.g. in *Metoligotoma*, *Notoligotoma*, and many Embiidae) add to the ability of the cercus as a clasping organ when adpressed to some other structure. Nodules may also occur on other structures, e.g. on the hypandrium in *Oligotoma glauerti* and *O. tillyardi*, probably adding to the efficiency of the hold when some other organ is adpressed to the nodulose surface.

The possibility of the extra lobe of the process of the left hemitergite in *O. tillyardi* being used to hold a spermatophore has been referred to earlier (Davis, 1936*a*, p. 242). Thus an extra lateral appendage to this process may act in three ways (1) as a guide to the left cercus, acting as a clasper; (2) as a guide to the 'ventral process', acting as in (1); (3) as the second lobe of a forcipate structure, not as an organ for clasping the female.

Several modifications of the left cercus-basipodite in *Metoligotoma* possess abilities as clasping organs, in somewhat different ways. The slightly concave and heavily chitinized outer face of the left cercus-basipodite in *M. extorris* forms the base against which the inner tooth of the left cercus is adpressed to act as a clasper; the spinous left cercus-basipodite in *M. illawarrae*, pressed against portion of the membrane of the female abdomen, with the left cercus bent inwards to hold the latter against it, must form a particularly efficient hold; and the bilobed left cercus-basipodite of *M. tasmanica biloba* forms a groove which guides the

* Ontogenetic studies in the Embiidae may reveal that this is homologous to the structure referred to as the left cercus-basipodite in the Oligotomidae.

downwardly-curved termination of the process of the left hemitergite, the approximation of these two structures forming a much more efficient clasping organ than in the case of *M. tasmanica tasmanica*, in which the process of the left hemitergite is pressed against the left cercus-basipodite without any guide to register against.

Differential characters in structures other than the male terminalia may be of some functional use. The tarsal bladders are probably of service when the insect darts backwards in its web gallery, an act performed by the huge levator tibiae muscles of the hind legs; the bladders are probably of use in disengaging the tarsal claws from the web, by dilation and the forcing upwards of the tarsus, and two would presumably be more efficient than one. Loss of wings in the male does not militate against powers of dispersal, as the female is wingless in all cases; wings in this Order may be regarded as a hindrance (to free motion in the galleries), and their loss facilitates the escape of the insect from predators. The most rapid movement possible in the gallery is backwards, not forwards, and the wings impede backward movement particularly. It has been observed in winged males of *Oligotoma gurneyi gurneyi* and *Notoligotoma nitens* that the wings are carried forward over the head during backward movement in the web, folding about a transverse line somewhat basad to a point half-way from articulation to termen. In these two species, probably throughout the family Oligotomidae, a definite hollow marks this line of folding, and this is present in specimens immediately after ecdysis, that is, it is genetic and not due to somatic modification.

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Corrigenda Part I, p. 238, figs. 18-24, *for* × 20, *read* × 16
Part II, p. 256, line 16, *for* 13.9.26, *read* 13.9.36

SALINITY TOLERANCE AND pH RANGE OF *CULEX FATIGANS* WIED., WITH NOTES ON THE ANAL PAPILLAE OF SALT-WATER MOSQUITOES.

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(One Text-figure.)

[Read 31st August, 1938.]

Salinity Tolerance.

Introduction.

The mosquito *Culex fatigans* Wied. has usually been regarded as a typical freshwater species. Prior to 1937, the only reference to the possibility of it breeding in saline waters was made by Hamlyn-Harris (1928), who mentioned that in Queensland this mosquito rarely breeds in brackish water. Recently Doctors Wanson and Nicolay (1937) stated that at Banana, on the coast of the Belgian Congo, "the larval cycle is accomplished normally in concentrations of up to 30 grams of chloride per litre". Taking this figure as representing the total chlorides present, the salinity (S‰) expressed as total weight of salts in grams per 1,000 grams of water, would be in the vicinity of 33·5, i.e., only slightly lower than normal sea-water. Experiments previously carried out by the author (Woodhill, 1936) showed that larvae were rapidly killed by sea-water of S‰ 35·5, but no lower salinities were tested at that time. In view of the statement by Wanson and Nicolay, more detailed series of experiments were recently carried out at the University of Sydney.

Laboratory cultures derived from naturally-occurring eggs were reared in various dilutions of sea-water, using tap-water of S‰ 0·06 as a control. The salinity of the sea-water was determined by titration against "normal" sea-water, according to the method given by Harvey (1928), and the dilutions were again titrated before use. The general technique of breeding, with a constant food supply, was similar to that previously described for *Aëdes concolor* (Woodhill, 1936).

Laboratory Experiments.

In the first series, eggs were allowed to hatch in tap-water (S‰ 0·06), and the first stage larvae were transferred to water of the desired salinity within 12 hours of hatching. The results are given in Table I.

It will be seen from Table I that the larvae developed normally in S‰ 9, that there was a slight but significant* reduction in S‰ 10, while a heavy mortality with considerable individual variation took place in S‰ 11.

* Assuming a binomial distribution the Standard Error is given by the formula

S.E. $= \sqrt{p \times q \times N}$

where p = the probability of adult emergence
q = 1-p = probability of non-emergence
N = number of individuals

The Standard Error of a difference $= \sqrt{SE_{(1)}^2 + SE_{(2)}^2}$

and if the difference between two means is greater than twice this figure the difference is assumed to be significant.

TABLE I.

1st instar larvae of C. fatigans *hatched in S‰ 0 and transferred within twelve hours to water of various salinities plus food. 20 larvae in each experiment. Constant temp. of 80° F.*

No. of Experiment.	S‰.	No. of 4th Inst. Larvae.	No. of Pupae.	No. of Adults.	Mean per cent. Adults.
1	0	20	20	20	
2	,,	18	18	18	
3	,,	19	19	19	97±1·71
4	,,	20	20	20	
5	,,	20	20	20	
6	9	20	20	20	
7	,,	20	20	20	
8	,,	20	20	20	99±0·995
9	,,	20	19	19	
10	,,	20	20	20	
11	10	20	20	20	
12	,,	15	15	15	
13	,,	17	17	16	86±3·46
14	,,	20	20	19	
15	,,	19	18	16	
16	11	10	10	10	
17	,,	3	3	2	
18	,,	5	5	5	30±4·58
19	,,	9	9	9	
20	,,	4	4	4	
21	12	0	—	—	
22	,,	0	—	—	
23	,,	1	1	1	1±0·995
24	,,	0	—	—	
25	,,	0	—	—	
26	13	0	—	—	
27	,,	0	—	—	
28	,,	0	—	—	0
29	,,	0	—	—	
30	,,	0	—	—	
31	30	0	—	—	
32	,,	0	—	—	0
33	,,	0	—	—	
34	,,	0	—	—	

Odd larvae may be able occasionally to develop in S‰ 12, while S‰ 13 is fatal to all larvae, death taking place within two days. In S‰ 30 the death of all larvae occurred within 8 hours. It is obvious that the critical point for 1st instar larvae is in the vicinity of S‰ 11.

In order to determine whether 4th instar larvae were any more resistant, bulk lots of larvae were bred through to the 4th instar in tap-water and then transferred to various salinities. The results are given in Table II.

TABLE II.

4th instar larvae of C. fatigans *bred in S‰ 0 and transferred to water of various salinities plus food. 20 larvae in each experiment. Constant temp. 80° F.*

No. of Experiment.	S‰.	No. of Pupae.	No. of Adults.	Mean per cent. Adults.
1	0	19	19	
2	,,	20	20	
3	,,	20	20	99±0·995
4	,,	20	20	
5	,,	20	20	
6	9	20	20	
7	,,	20	20	
8	,,	18	18	98±1·40
9	,,	20	20	
10	,,	20	20	
11	10	17	13	
12	,,	19	19	
13	,,	17	17	88±3·25
14	,,	19	19	
15	,,	20	20	
16	11	13	9	
17	,,	11	11	
18	,,	10	8	49±5·0
19	,,	11	11	
20	,,	10	10	
21	12	4	1	
22	,,	4	3	
23	,,	0	0	7±2·55
24	,,	5	1	
25	,,	3	2	
26	13	0	—	
27	,,	0	—	
28	,,	0	—	0
29	,,	0	—	
30	,,	0	—	
31	30	0	—	
32	,,	0	—	
33	,,	0	—	0
34	,,	0	—	
35	,,	0	—	

From Table II it is evident that there is a slight increase in resistance to salinity in 4th instar larvae, as compared to 1st instar larvae, since there is a significant difference between the mean percentage surviving in each group in S‰ 11.

A series of experiments was then carried out to determine whether the salinity tolerance could be altered by gradually increasing the salinity of the water. The results are given in Table III.

TABLE III.

Larvae of C. fatigans *subjected to gradual increases in salinity. 20 larvae in each experiment plus food. Constant temp. 80° F.*

No. of Exp.	Salinity in which various instars were passed. Figures = S‰. Eggs and 1st inst.	2nd inst.	3rd inst.	4th inst.	No. of Pupae.	No. of Adults.	Mean per cent. Adults.
1	9	10	11	11	15	15	
2	,,	,,	,,	,,	14	11	
3	,,	,,	,,	,,	16	12	64±4·79
4	,,	,,	,,	,,	14	12	
5	,,	,,	,,	,,	14	14	
6	9	10	11	12·5	6	4	
7	,,	,,	,,	,,	6	5	
8	,,	,,	,,	,,	6	3	16±3·66
9	,,	,,	,,	,,	4	1	
10	,,	,,	,,	,,	5	3	
11	9	10	11	12·5→14	1	1	
12	,,	,,	,,	,, ,,	3	3	
13	,,	,,	,,	,, ,,	4	4	17±3·76
14	,,	,,	,,	,, ,,	5	5	
15	,,	,,	,,	,, ,,	4	4	
16	9	10	11	12·5→14→16	0	—	
17	,,	,,	,,	,, ,, ,,	0	—	
18	,,	,,	,,	,, ,, ,,	0	—	0
19	,,	,,	,,	,, ,, ,,	0	—	
20	,,	,,	,,	,, ,, ,,	0	—	

It will be seen from Table III that some adaptation to increasing salinity takes place, since there is a significant difference between the number of adults produced in S‰ 11 in Table III as compared with Table II. In addition, 17% of adults were produced in S‰ 14 when the increase was gradual, whereas no adults were obtained from S‰ 13 when 4th instar larvae were transferred directly.

TABLE IV.

Pupae of C. fatigans *bred in tap-water (S‰ 0) and transferred to various salinities. 20 pupae in each experiment. Constant temp. 80° F.*

No. of Experiment.	S‰.	No. of Adults.	Mean per cent. Adults.
1	35·5	19	
2	,,	20	
3	,,	18	97±1·71
4	,,	20	
5	,,	20	
6	71·0	19	
7	,,	20	
8	,,	20	99±0·995
9	,,	20	
10	,,	20	
11	105·0	17	
12	,,	18	86·6±2·69
13	,,	17	

The effect of increased salinity on the pupae is, however, quite different. Larvae were bred through to the pupal stage in tap-water (S‰ 0) and transferred to various concentrations of sea-water as soon as the pupae were fully pigmented. The results are shown in Table IV.

It is obvious from Table IV that pupae can withstand an abrupt change from fresh water to water of approximately three times the concentration of normal sea-water and are quite independent of the osmotic pressure of the surrounding medium.

Finally, a few experiments were carried out to determine the effect of a solution of sodium chloride on the larvae. The results are shown in Table V.

TABLE V.

1st instar larvae of C. fatigans, *hatched in S‰ 0 and transferred within 12 hours. 20 larvae in each experiment. Constant temp. 80° F.*

No. of Experiment.	Solution.	No. of 4th Inst. Larvae.	No. of Pupae.	No. of Adults.	Mean per cent. Adults.
1	NaCl in dist. water, 10 gm. per litre.	0	—	—	0
2	,,	0	—	—	
3	,,	0	—	—	
4	,,	0	—	—	
5	Dist. water.	20	20	20	95
6	,,	19	18	18	

From Table V it will be noted that all larvae are killed by a solution of pure sodium chloride of a salinity of 10 gm. per litre, whereas they develop normally in a balanced solution of S‰ 10, i.e., diluted sea-water. This confirms the experiments carried out by previous workers on other species of mosquitoes.

Influence of Salinity Changes on Developmental Period.

In water of S‰ 0 to S‰ 10 at 80° F. the period from hatching to adult emergence varied from 8 to 12 days, and in S‰ 11 to S‰ 14 from 9 to 13 days. It is apparent, therefore, that increased salinity does not retard development to any great extent.

Discussion.

Taking the results of Tables I to V, it is found that the reaction of *Culex fatigans* to saline water is such as one would expect from a typical freshwater mosquito. The results agree in a general way with those of Wigglesworth (1933, *a* and *b*) for the larvae of *Aëdes* (*Stegomyia*) *aegypti*, but cannot be accurately compared since in those experiments the larvae were not in all cases bred through to the adult stage.

As shown by the same author, the critical point appears to be reached when the osmotic pressure of the environment becomes slightly greater than that of the haemolymph.

Changes in the walls of the anal papillae, similar to those described by Wigglesworth in *A. aegypti*, were observed in S‰ 11 to S‰ 15, with considerable individual variation. When 3rd instar larvae were transferred from S‰ 10 to S‰ 13·5 the anal papillae were frequently destroyed, and when the larvae were transferred back to S‰ 10, development to the adult stage took place without anal papillae.

Although some 3rd instar larvae can develop to the adult stage without anal papillae, the evidence so far available indicates that all those species normally found in salt water have anal papillae either reduced or absent.

The three species in the Sydney district which are frequently found in salt water, *Aëdes* (*Mucidus*) *alternans* West, *Aëdes* (*Ochlerotatus*) *vigilax* Sk., and *Aëdes* (*Pseudoskusea*) *concolor* Tayl., all have anal papillae reduced or absent, and this is also the case with a New Zealand salt-water species *Opifex fuscus* Hutton.

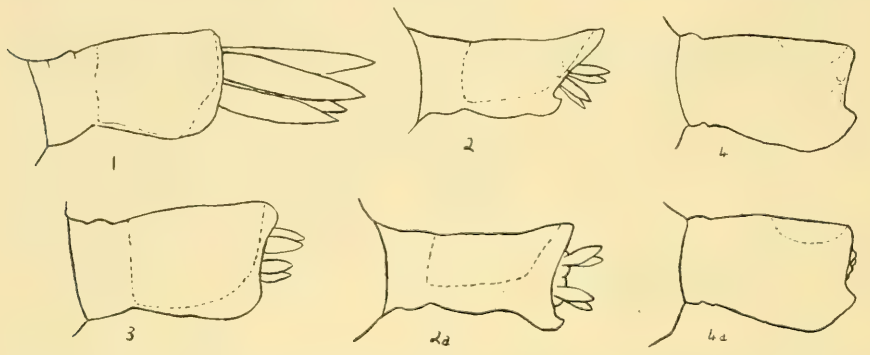

Fig. 1.

(1) *Culex fatigans*, (2) *Aëdes alternans*, normal appearance, (2*a*) *A. alternans* with rectum protruding, (3) *Aëdes vigilax*, (4) *Aëdes concolor*, normal appearance, (4*a*) *A. concolor*, with rectum protruding.

In Figure 1 the relative length of the anal papillae and the terminal segment of *C. fatigans* and the three salt-water species is shown. The appearance varies greatly according to whether the rectum is protruded or retracted. The structures previously termed rudimentary anal papillae in *A. concolor* are considered by the writer not to be homologous with the anal papillae but with internal rectal papillae. They are only evident externally when faeces are passed or when the larva is squeezed or preserved in strong fixative. Normally they are hidden within the anal opening. Similar structures, along with true anal papillae, can be seen in the figures of *A. alternans* (2 and 2*a*). Mosquito larvae when placed alive in strong fixative frequently protrude the rectum and lose the anal papillae, and these internal structures can then readily be mistaken for small anal papillae and have sometimes been figured as such.

The results of these experiments do not confirm those given by Wanson and Nicolay for *C. fatigans* in the Belgian Congo. If a biological race of *C. fatigans*, capable of breeding in salt water, exists there, one would expect the anal papillae to be very much reduced, as the result of a racial difference, or completely lacking owing to loss during the life of the individual. Wigglesworth (1938) has shown that even in water of S‰ 9 the anal papillae of *C. pipiens* are greatly reduced in size.

On the other hand, it would be possible to obtain adults of *C. fatigans* from natural waters of a very high salinity, provided that the influx of salt water took place after the pupae had developed.

The pH Range.

Introduction.

A considerable amount of work has been carried out on the pH range of *C. fatigans*, and this has been summarized by Senior White (1934). The results

from both field observations and laboratory experiments have given very conflicting results, some authors stating that acidity was fatal, while others found that the larvae were killed by a high alkalinity. In some laboratory experiments the acidity was produced by fermenting material such as banana pulp, while in others the chemicals used to control the pH were definite larvae poisons, and no attention was paid to the quantity or nature of the food available for the larvae. It seems obvious that factors other than the changed pH were operating in many of these experiments.

Laboratory Experiments.

In the following series of experiments the same standard food as previously used by the author (Woodhill, 1936) was supplied throughout in a measured quantity of water. The control series were put up in tap-water plus food, the pH of the mixture remaining between 6·4 and 6·8. The pH of this mixture was altered by the addition of small quantities of acetic acid or sodium hydroxide. It was found that the pH could readily be kept between 3·6 and 4·2 by the addition of 2·5 c.c. acetic acid (E) per litre, and between 3·4 and 3·6 by adding 5 c.c. per litre. As was to be expected, it was more difficult to maintain a high pH. When water containing 40 c.c. $\frac{N}{20}$ NaOH per litre was used, the pH varied from 10·6 to 7·6, even when changed twice weekly. In order to keep the pH above 9·0 it was found necessary to use 100 c.c. $\frac{N}{20}$ NaOH per litre, changing the water twice weekly.

The results of these experiments are shown in Table VI.

TABLE VI.

1st instar larvae of C. fatigans, *hatched in tap-water and transferred within 12 hours. 20 larvae in each experiment. Constant temp. 80° F.*

No. of Experiment.	Water.	No. of 4th Instar.	No. of Pupae.	No. of Adults.	Average per cent. Adults.
1	5 c.c. Acetic (E)	3	3	3	
2	per litre	4	4	4	21·25
3	pH range	7	7	7	
4	3·4 to 3·6	4	3	3	
5	2·5 c.c. Acetic (E)	20	20	20	
6	per litre	20	20	20	98·75
7	pH range	19	19	19	
8	3·6 to 4·2	20	20	20	
9	40 c.c. $\frac{N}{20}$ NaOH	20	19	19	
10	per litre	20	20	20	96·25
11	pH range	20	20	20	
12	>10·6 to 7·6	20	19	18	
13	100 c.c. $\frac{N}{20}$ NaOH	19	19	19	
14	per litre	20	20	20	97·5
15	pH range	20	19	19	
16	>10·6 to 9·0	20	20	20	
17	Tap-water	20	20	20	
18	pH range	20	20	20	98·75
19	6·4 to 6·8	20	20	20	
20		20	20	19	

It will be noted from Table VI that a normal percentage of adults developed from water with a pH varying from 3·6 to 4·2, 6·4 to 6·8, 7·6 to 10·6 and 9·0 to 10·6.

A significant reduction in number of adults took place in water of pH 3·4 to 3·6, but this result is not necessarily due to the direct effect of the low pH on the larvae, but may be due to its effect on the bacterial flora or to the direct effect of the excess acetic acid on the larvae. Senior White (1934) records larvae and pupae of *C. fatigans* in a tank of dilute hydrochloric acid with a pH of 1·6.

It is obvious therefore that any variation in pH between 4·2 and 9·0 does not prevent the development of *C. fatigans*.

Influence of pH Changes on Developmental Period.

The following gives the maximum and minimum periods from hatching to the emergence of adults at 80° F.

pH Range.	Period in Days.	
	Min.	Max.
3·4 to 3·6	15	17
3·6 to 4·2	11	16
6·4 to 6·8	8	12
7·6 to 10·6	11	16
9·0 to 10·6	11	16

It will be seen that a considerable change from the normal towards either acidity or alkalinity slightly retards the development, but from the data at present available it is not possible to say whether this is a direct effect on the larvae, or whether it acts indirectly by retarding the development of bacteria.

Summary.

(1) The statement by Doctors Wanson and Nicolay that *Culex fatigans* in the Belgian Congo develops normally in water containing 30 grams of chloride per litre has not been confirmed by experiments with the same species in Australia.

(2) 1st or 4th instar larvae, when transferred from tap-water direct to diluted sea-water, will not develop normally in concentrations greater than 10 gm. of salts per litre, and no adults develop in water containing 13 gm. of salts per litre.

(3) When the salinity of the water is gradually raised, a few adults develop in water containing 14 gm. per litre.

(4) Under no circumstances do any adults develop from larvae in water containing 16 gm. or more of salts per litre.

(5) Larvae will not develop in water containing 10 gm. of NaCl per litre with no other salts present.

(6) A comparison of the length of the anal papillae in relation to the terminal segment shows that all the species of mosquito larvae commonly found in salt or brackish water in Australia and New Zealand have anal papillae reduced or absent.

(7) The structures formerly referred to as rudimentary anal papillae in *Aëdes* (*Pseudoskusea*) *concolor* Tayl. are considered to be homologous with internal rectal papillae.

(8) Pupae are independent of the salinity of the water and will develop to adults in water containing 105 gm. of salts per litre.

(9) Variation of the pH of the water from 6·8 to either 4·2 or 9·0 slightly retards the development of the larvae to the adult stage, but has no effect on the total number of adults produced.

The author's thanks are due to Mr. F. C. McCleery for advice on methods of statistical analysis, and to Mr. F. H. Taylor for confirming the identification of the species.

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FISHES FROM NAURU, GILBERT ISLANDS, OCEANIA.

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(Plate xiv; three Text-figures.)

[Read 31st August, 1938.]

Nauru or Pleasant Island, sometimes called Nawodo or Shank Island, is the westernmost of the Gilbert Islands in Oceania. It was discovered by Captain Fearn of the "*Hunter*" in the 1790's, and is situated in Lat. 0° 25′ S., Long. 167° 05′ E.

Its nearest neighbour is Ocean Island, which will therefore be considered along with Nauru as a single faunal region. Ocean Island has also been named Bonabe, Panopea, Baanopa, or Paanopa, but should not be confused with Ponapé or Ponapi (i.e., Puynepet Island) in the Carolines, or with Ocean Island in the Hawaiian group. The Ocean Island with which we are concerned is in Lat. 0° 52′ 02″ S. and Long. 169° 35′ E. It was discovered in 1804 from the ship "*Ocean*".

The fishes of Nauru and Ocean Island are identical with species recorded from the Carolines, Gilberts, and Santa Cruz Islands. They belong therefore to the Garrettian Province of the Melanesian Marine Region. Those interested in the relationships of this province to the faunas of Australian seas may refer to the section on zoogeography in the *Australian Zoologist*, viii, 4, 1937, pp. 268-272.

Because of the isolated position of Nauru and Ocean Islands, very few naturalists or collectors have visited them. The first contribution to our knowledge of their zoology was made when, some thirty or forty years ago, Messrs. F. Danvers Power and A. E. Stephen visited them on behalf of the Pacific Islands Company. They brought back to Sydney some birds, reptiles, fishes, molluscs, arthropods, crustacea, and echinoderms, and most of their specimens are still preserved in the Australian Museum. The fishes were registered nos. I.5016 to 5042 and 5046 to 5052, and on this basis Waite wrote the first list of the fishes from these regions, recording (1903) from Pleasant Island (Nauru): *Gymnothorax pictus* Ahl., *Fistularia depressa* Günther, *Mulloides samoensis* Günther, *Caranx hippos* Linnaeus (regarded as poisonous at times!), *Anthias pleurotaenia* Bleeker, *Cirrhites maculatus* Lacépède, *Glyphidodon brownriggii* Bennett, *Thalassoma purpurea* Forskal, *Thalassoma melanochir* Bleeker, *Teuthis lineatus* Linnaeus, *Teuthis triostegus* Linnaeus, *Naseus unicornis* Forskal, *Salarias periophthalmus* Cuvier and Valenciennes, and *Rhomboidichthys pantherinus* Rüppell; and from Ocean Island (Paanopa): *Gymnothorax flavomarginatus* Rüppell, *Gymnothorax tessellatus* Richardson, *Tylosurus platurus* Rüppell (? = *Belone depressa* Günther), *Fistularia depressa* Günther, *Holocentrus erythroeus* Günther (native name *Te breno*), *Promethichthys prometheus* Cuvier and Valenciennes, *Caranx hippos* Linnaeus, *Kuhlia taeniura* Cuvier and Valenciennes, *Epinephelus merra* Bloch, *Teuthis triostegus* Linnaeus, *Gobius albopunctatus* Cuvier and Valenciennes, and *Salarias meleagris* Cuvier and Valenciennes.

* Contribution from the Australian Museum.

To the above list Waite added, "The following are given as native names at Ocean Island; as specimens were not obtained the species cannot be given. Hammer-headed Shark, *Te-pakoa te anoa.* Tiger Shark, *Emurr.* Flying Fish, *Te-nouti.* Palu, *Te-kanebek.*

"The last-named, of which I have seen a photograph, is *Ruvettus pretiosus*, Cocco, a species I first recorded from the South Pacific (Waite, *Aust. Mus. Mem.*, iii, 1899, p. 539)."

The Australian Museum series of fishes which had been utilized by Waite remained until recently the only collection, so far as we can trace, ever made and reported upon from Ocean and Pleasant Islands, and it appears that this Museum is the only one in which fishes from those islands are preserved. Thus authors on the fishes of Oceania have added no further records to those of Waite, unless by way of bringing his nomenclature more up to date or reclassifying a few small specimens which he left untouched.

Fowler (1928) includes the fishes of Ocean and Pleasant Islands as follows: *Lycodontis picta* (Ahl.) (p. 51), *Lycodontis flavomarginata* (Rüppell) (p. 55), *Lycodontis favaginea* (Schneider) (= *Gymnothorax tessellatus* in Waite) (p. 57), *Strongylura tahitiensis* Fowler & Bean (= *Tylosurus platurus* Waite) (p. 73), *Platophrys pantherinus* (Rüppell) (p. 91), *Holocentrus erythraeus* Günther (p. 99), *Fistularia petimba* Lacépède (p. 117), *Promethichthys prometheus* (Cuvier) (p. 135), *Ruvettus pretiosus* Cocco (p. 135), *Caranx ignobilis* Forskal (= *C. hippos* in Waite) (p. 148), *Kuhlia taeniura* (Cuvier) (p. 171), *Serranus merra* (Bloch) (p. 181), *Anthias pleurotaenia* Bleeker (p. 186), *Mulloides samoensis* Günther (p. 234), *Cirrhitus pinnulatus* (Bloch & Schneider) (= *C. maculatus* in Waite) (p. 237), *Hepatus triostegus* (Linné) (p. 264), *Hepatus lineatus* (Linné) (p. 269), *Naso unicornis* (Forskal) (p. 277), *Abudefduf biocellatus* (Quoy & Gaimard) (= *Glyphidodon brownriggii* in Waite) (p. 321), *Thalassoma purpureum* (Forskal) (p. 353), *Thalassoma melanochir* (Bleeker) (p. 355), *Bathygobius fuscus* (Rüppell) (= *Gobius albopunctatus* in Waite) (p. 405), *Salarias periophthalmus* Valenciennes (p. 439), *Salarias meleagris* Valenciennes (p. 440).

In 1931 Fowler issued his first supplement to "The Fishes of Oceania", but there are no fishes from Ocean or Pleasant Island in that paper. However, in Supplement 2, Fowler (1934) lists some species from these islands from a manuscript catalogue of the fishes from Oceania in the Australian Museum. Here, therefore, we find recorded: *Chanos chanos* (Forskal), "Introduced" (p. 386), *Lycodontis flavomarginata* (Rüppell) (p. 390), *Lycodontis favaginea* (Schneider) (p. 390), *Belone platura* Bennett (p. 392), *Platophrys pantherinus* (Rüppell) (p. 394), *Fistularia petimba* Lacépède (p. 398), *Promethichthys prometheus* (Cuvier), 530 mm. long (p. 400), *Serranus merra* (Bloch) (p. 410), *Anthias pleurotaenia* Bleeker (p. 411), *Cirrhitus pinnulatus* (Schneider) (p. 422), *Thalassoma quinquevittatus* (Lay & Bennett) (p. 438), *Thalassoma melanochir* (Bleeker) (p. 438), *Bathygobius fuscus* (Rüppell) (p. 442), *Salarias periophthalmus* Valenciennes (p. 446).

We have considered it necessary to list the above records in detail to avoid the necessity of searching again through nearly seven hundred large double-columned pages in Fowler's works.

Whitley (1935, p. 233) gave the results of his examination of some "old collection" percoids in the Australian Museum from Nauru. These had evidently formed part of Waite's original series, but had been left unclassified. They were thereupon determined as novelties and one was named *Chromanthias exilis* (family

Anthiidae) and another species was left until now before being described as new. He also noted that Waite's *Anthias pleurotaenia* Bleeker belonged to the genus *Pseudanthias*. When dealing with devil rays, the same author (*Austr. Mus. Mag.*, vi, 1936, p. 11, and Whitley, 1936, p. 181) quoted an account of a Nauruan Devil Ray, tentatively identified as *Manta? banksiana* (Lacépède). A File Fish, *Sufflamen fraenatus* (Latreille) was recorded from Nauru (Whitley, 1937).

A. F. Ellis (1936) gave a plate (opposite p. 177) of a Marlin swordfish from Nauru and discussed fishing methods in general. A more scientific account of the fisheries was given in the same year by Kayser (1936, p. 92). See also Power, *Aust. Naturalist*, Jan., 1916, 115–6.

Also in 1936, photographs of a large Nauruan shark were submitted to us for identification and determined as a species of *Echinorhinus*, though, as the specimen was not preserved or measured, exact specific identification was impracticable. It was interesting, however, to find this genus of sharks in Oceania.

The above gives a résumé of our knowledge of the fish-fauna of Ocean and Pleasant Islands down to recent years, when further collections have been made and submitted to us for identification and report. For these we are indebted to Professor W. J. Dakin, who made an extensive collection during his visit to the Island in 1934, to Rupert C. Garsia, Esq., the Administrator, who has forwarded specimens from time to time, and finally to Professor Harvey Sutton, who made a collection with the object of determining the food values of the different species used in the Hospital Kitchen. Professor Sutton secured these fish during a recent visit (March, 1937) and was good enough to hand them to us for identification.

The collections made by these gentlemen duplicate some of Waite's species, indicating, as one would expect, that these are constant or common at Nauru, but they also contain some interesting new records as detailed hereunder.

We are indebted to Commander Rupert C. Garsia, Administrator of Nauru, for supplying us with the native names of the fishes. These are quite unlike the native names given to these, or allied, species in Hawaii, Tahiti, Rarotonga, and elsewhere. It is noteworthy that more than one native name may be applied to what a systematist would consider to be a single species of fish.

In this paper we do not presume to give a comprehensive list of the fishes of Nauru, though we include all the species so far known from there. If that island is like most of the others in Oceania, it probably supports a fauna of several hundred species, whereas our list includes 74 species. Neither do we give full references to literature or lengthy synonymies, as these may be found in the many excellent treatises on Indo-Pacific fishes. Some changes in the scientific nomenclature of many of the fishes of Oceania will have to be made at no distant date, as all authorities realize, but we have felt that, at this stage, it were better to postpone making more drastic alterations until further revision of some of the genera (e.g., "*Teuthis*" and "*Caranx*") be attempted in the future. The preserved material in the Australian Museum is registered under the following numbers: I.5016 to 5042; I.5046 to 5052; I.6681 to 6682; IA.6990 to 7021; IA.7125 to 7178.

Family Echinorhinidae.

Genus Echinorhinus Blainville, 1816.

1. Echinorhinus sp. Bramble shark.

Photographs of a large shark from Nauru have been identified as representing this distinctive genus, which has not hitherto been recorded from Oceania.

Unfortunately no detailed measurements, teeth or other parts, were secured, so that the species cannot be identified. The length was said to have been 10 feet.

Nauru (A. S. Lloyd); September, 1936.

Family Sphyrnidae.

Genus Sphyrna Rafinesque, 1810.

2. Sphyrna zygaena (Linné). Te-pakoa te anoa; Hammerhead Shark.

In the absence of specimens or detailed measurements and photographs, we can only surmise that the Hammerhead Shark may be this species.

Ocean I. (Waite).

[(2*a*) Waite also recorded a Tiger Shark or *Emurr* from Ocean Island, but it is impossible without a specimen to say even to what family this belongs.]

Family Ceratopteridae.

Genus Manta Bancroft, 1829.

3. Manta banksiana (Lacépède). Devil Ray.

Raja banksiana Lacépède, *Hist. Nat. Poiss.*, ii, 1800, p. 105, Pl. v, fig. 3. East Indies.—*Manta banksiana* Whitley, *Austr. Zool.*, viii, 1936, p. 180.

A Devil Ray, 8½ feet across the pectoral fins, was found washed up on the reef at Nauru in 1935 by Mr. F. H. Davies. It was a female, containing an embryo, but unfortunately no parts of the specimen have been preserved.

Nauru (Davies).

Family Chanidae.

Genus Chanos Lacépède, 1803.

4. Chanos chanos (Bonnaterre). Ibija; Milk Fish (Bañgos of the Philippines).

Chanos chanos Fowler, *Mem. Bish. Mus.*, xi, 6, 1934, p. 386.

Nauru (Dakin). Australian Museum registered numbers IA.7125–6. Two specimens from Fish Pond. For a reference to the Ibija fisheries, *vide infra*, p. 303.

Family Muraenidae.

Genus Gymnothorax Bloch, 1795.

5. Gymnothorax flavimarginatus (Rüppell). Reef Eel.

Gymnothorax flavomarginatus Waite.—*Lycodontis flavomarginata* Fowler, 1928 and 1934.

Ocean I. (Waite).

6. Gymnothorax favagineus (Bloch & Schneider). Spotted Reef Eel.

Gymnothorax tessellatus Waite.—*Lycodontis favaginea* Fowler, 1928 and 1934.

Ocean I. (Waite).

7. Gymnothorax zonipectis Seale. Etari; Reef Eel.

Nauru (Dakin). IA.6991.

8. Gymnothorax dakini, n. sp. Earuero; Dakin's Reef Eel. Pl. xiv, fig. 2.

A Reef Eel in the Nauru collection bears the native name Earuero, but requires a new scientific name since it does not agree with descriptions, figures, or specimens of any Indo-Pacific species known to us. We therefore have much pleasure in naming it in honour of Professor W. J. Dakin, D.Sc., to whom we are indebted for the fine series of fishes he secured. The measurements given below are approximate, since, as is usual with eels, the specimen is rather distorted in preservative.

Head (61 mm.) 9·4, depth of trunk (54) 10·6 in total length (576). Distance from snout to anus (240) 1·4 in tail (336). Head 2·9 in trunk (179). Eye (5) 2 in snout (10) which is greater than interorbital (8·5). Gape (22) 2·77 in head.

Top of head bulbous; snout blunt and short; eye small, its diameter less than that of gill-opening. Anterior nostrils tubular, but without flaps; posterior nostrils pore-like. A few open mucus pores around jaws. Mouth reaching backward well behind eye. Teeth conic, without serrations. None of them is granular or molar-like: they are pointed fangs, those on roof of mouth being depressible. They extend in an even row round the upper jaw and intermaxillary, and there is a series of about seven rather larger maxillary fangs forming an inner row on each side. About four enlarged teeth behind the intermaxillary ones. A well developed row of teeth on each side of vomer. Mandibular teeth in a single row laterally, but anteriorly there are several inner teeth grouped asymmetrically, giving a bi- or tri-serial appearance. Throat with a few longitudinal furrows.

Body elongate, rather robust anteriorly, becoming compressed towards end of tail. The skin is smooth and tough and puckered into numerous scale-like folds. Anus large, in anterior half of fish. Dorsal fin originating before vertical of gill-openings and continuing to the caudal. It is very little elevated and is so invested with adipose tissue that the rays cannot be felt. Anal similar to dorsal, originating a short distance behind vent. Caudal fin very small. Colour, in formalin, pale yellowish-brown, lightest on snout and belly. This ground colour is mottled with darker on body and there is a faint lilac tinge on the dark posterior part of the head and towards end of tail. Edges of fins pale dirty-yellowish, not mottled. Teeth brown. No cross-bands or striking coloration; no dark patch at gill-openings or at rictus.

Described and figured from the holotype of the species, a specimen 576 mm. long, from Nauru, Gilbert Islands, Oceania (Professor Dakin). Australian Museum registered no. IA.6990.

The blunt snout, dentition (as described), and small eye are useful recognition marks.

9. Gymnothorax garsiae, n. sp. Garsia's Reef Eel. Pl. xiv, fig. 3.

One specimen of a small, very dark coloured Reef Eel appears to represent an undescribed species, with which we have pleasure in associating the name of Commander Rupert C. Garsia, Administrator of Nauru, in appreciation of his assistance to all concerned in making this collection.

Head (16 mm.) 8, depth of body (8) 16 in total length (129). Head and trunk (59) nearly 1·2 in tail (70). Eye (1) 3 in snout (3). Gape (6) 2·6 in head.

General characters as for most species of *Gymnothorax*, but the size is small, and the body not very compressed. Dorsal fin commencing before level of gill-openings, anal just behind vent, both fins being well developed and confluent with the caudal. The teeth are long, acute fangs, largest anteriorly. One very large depressible fang behind the intermaxillary series and before the single vomerine row of smaller teeth. An inner lateral series of four fangs on each side of maxillary teeth.

Coloration uniform, without bands or spots. Very dark brown to blackish, with a narrow edging of white around the tip of the confluent fins around end of tail.

Holotype registered no. IA.7171 in the Australian Museum. Collected on the reef flat at Nauru for Professor Harvey Sutton. Total length 129 mm.

Genus Anarchias Jordan & Seale, 1906.

10. Anarchias knighti Jordan & Seale. Deduwiduw; Reef Eel.

Anarchias knighti Jordan & Seale, *Bull. U.S. Bur. Fisheries*, xxv, 1905 (Dec. 15, 1906), p. 205, fig. 10. *Ex* Jordan and Starks MS. Samoa.

One specimen, about 200 mm. long, of this small reef eel, which is distinguished by having no anal fin.

Nauru (Sutton). IA.7162.

Genus Siderea Kaup, 1856.

11. Siderea picta (Thunberg). Eamwit or Egamagamoe; Reef Eel.
Gymnothorax pictus Waite.—*Lycodontis picta* Fowler.
Nauru (Waite; Dakin). IA.6992 and IA.7147-8. One (IA.6992) as *Egamagamoe*, and two (IA.7147-8) labelled as Reef Snake, *Eamwit*.

Family Ophichthyidae.
Genus Leiuranus Bleeker, 1852.

12. Leiuranus semicinctus (Lay & Bennett). Deimon; Snake Eel.
One specimen, 212 mm. long, with 29 dark bands.
Nauru (Sutton). IA.7163.

Family Aulostomatidae.
Genus Aulostomus Lacépède, 1803.

13. Aulostomus chinensis (Linné). Edabweo; Painted Flute-mouth.
Nauru (Dakin). IA.6993.

Family Fistulariidae.
Genus Fistularia Linné, 1758.

14. Fistularia depressa Günther. Dabweo; Flutemouth.
Fistularia depressa Waite.—*Fistularia petimba* Fowler, 1928 and 1934.
Nauru (Waite). Ocean I. (Waite).

Family Belonidae.
Genus Platybelone Fowler, 1919.

15. Platybelone platura (Bennett). Emwa; Long Tom.
Tylosurus platurus Waite.—*Strongylura tahitiensis* Fowler, 1928.—*Belone platura* Fowler 1934.
Ocean I. (Waite). Nauru (Dakin; IA.6996).

Family Hemiramphidae.
Genus Hemiramphus Cuvier, 1816.

16. Hemiramphus marginatus (Bonnaterre). Emwaijeb; Garfish.
One specimen, identified as the *H. marginatus* of authors.
Nauru (Dakin). IA.6994.

Family Exocoetidae.
Maculocoetus, n. gen.

Orthotype, *Maculocoetus suttoni*, n. sp.

The genus represented by our Nauruan flying fishes requires separation from the true *Cypsilurus* of Swainson (Nat. Hist. Class. Fish, Amphib. & Rept., i, Oct., 1838, p. 299, fig. 63) because that name was introduced for a "bearded" juvenile of an American species regarded by Bruun (Dana Rep., vi, 1935, p. 52) as the young of *C. comatus* (Mitchill). The genotypical species differs from ours in the absence of the dark spot on the dorsal fin, the smaller number of predorsal scales (26:38–40), presence of palatine teeth, and a number of minor characters.

Bruun (*loc. cit.*, p. 84) subdivided *Cypsilurus* into four subgenera. Our species comes nearest to *C. lineatus* in his key and would thus appear to enter his subgenus

Procypsilurus, which is synonymous with *Exonautes* Jordan and Evermann (see Whitley, *Rec. Aust. Mus.*, xx, 1937, p. 11). The genotype of *Procypsilurus* = *Exonautes*, is *Exocoethus exsiliens* Linné 1771, from Carolina, which differs from our species in the smaller number of predorsal scales (29:38–40), and in the larger number of vertebrae (*C. exsiliens* 44–45, *Maculocoetus suttoni* 42).

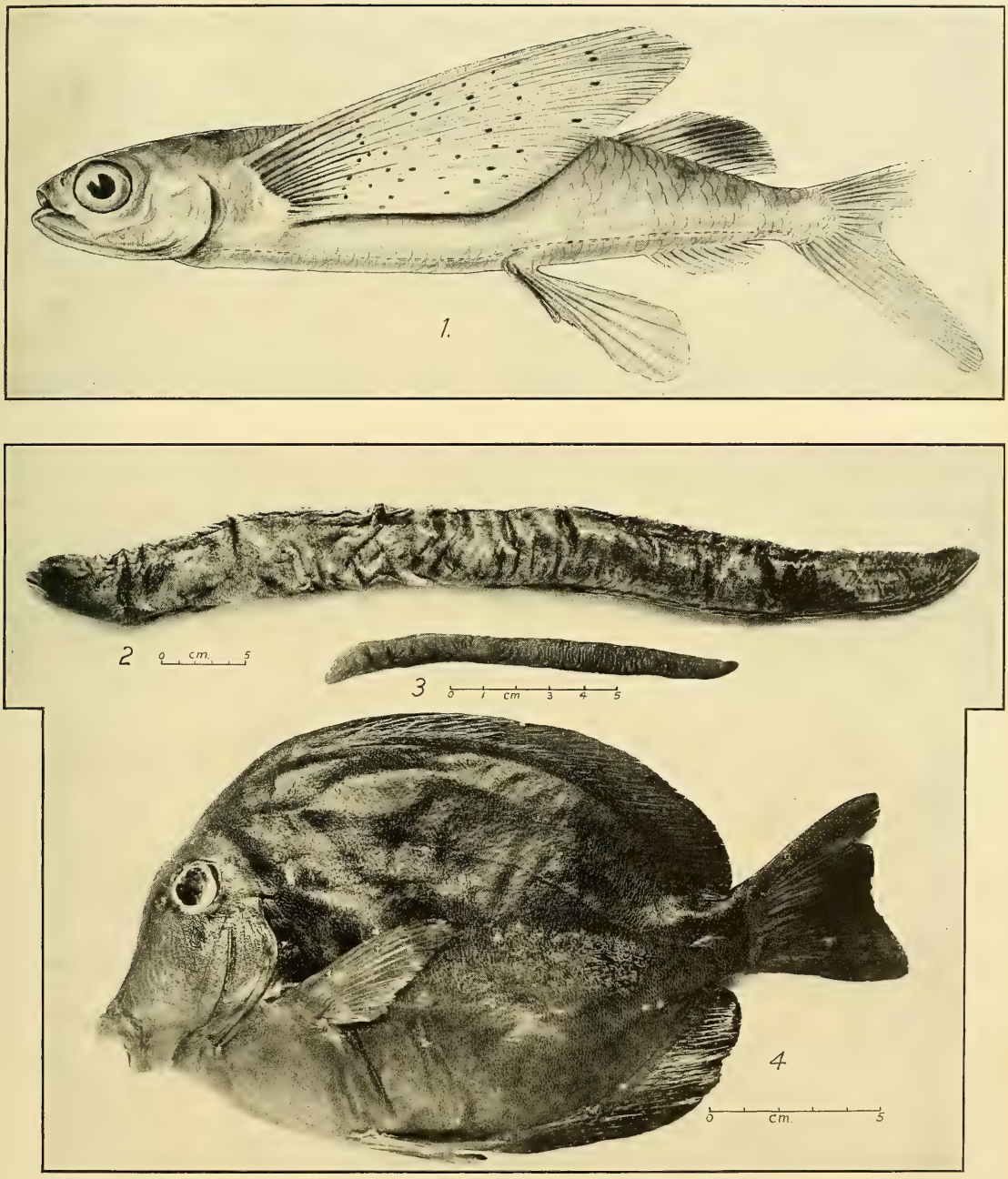
Our new genus includes *atrisignis* Jenkins, probably *spilopterus* C. & V., and probably *poecilopterus* C. & V. The systematic description of the new form is as follows:

17. Maculocoetus suttoni, n. sp. Emor or Te-nouti; Flying Fish. Plate xiv, fig. 1.

Head 4·6 in length; depth 5·2; D.12; A.10; P.12–13; lateral line 68–70 scales; predorsal scales 38–40; scales between origin of dorsal and lateral line 9.

Body elongate, broadest at about half-way between origin of pectorals and origin of dorsal. Posterior portion of head broad dorsally, tapering somewhat towards snout; interorbital space slightly concave and covered by rugose scales. Interorbital space less than distance from opercle margin to eye margin. Eye large, its centre anterior to centre of head. Snout less than eye diameter, lower jaw slightly protruding, maxilla included and falling short of anterior margin of eye. Pectorals reach beyond the tip of last dorsal ray (on the type specimen the ends of the pectoral rays were broken off, so this character was confirmed from the paratype). Second pectoral ray branched. Ventrals reach to about two-thirds the base of the anal, their origin being nearer to the base of the caudal than to the eye margin (13:10). Origin of dorsal very little in advance of the vent (almost opposite), its distance from the first caudal ray being 1·2 times the head-length. Longest dorsal ray 2 in head. Lower caudal lobe the longer. The proportions and numerical characters of the type specimen, and of two additional individuals are set forth in the table below.

	Type No. IA.6996. Nauru.		No. IA.7142. Nauru.		No. IA.7143. Nauru.	
Ventral rays	7		7		7	
Dorsal rays	12		12–13		12	
Anal rays	10		10		10	
Pectoral rays	12–13		13–14		12–13	
Vertebrae	—		—		42	
Gill rakers	—		—		29	
Predorsal scales	38–40		ca. 37		ca. 38	
Transverse scales (mid-dorsal to l. lat.)	9		9		9	
	mm.	% S.L.	mm.	% S.L.	mm.	% S.L.
Standard length	260	—	270	—	260	—
Preanal length	199	76	210	78	200	76
Predorsal length	178	68	180	67	180	68
Preventral length	145	56	150	56	150	58
Head length	61	23	64	24	62	24
Snout length	13	5	15	5	15	6
Pectoral length	152	58	190	70	175	66
Ventral length	70	27	70	26	72	27
Dorsal height	26	10	21	8	21	8
Body height	50	19	50	18	50	19
Body breadth	39	15	35	13	35	13
Interorbital breadth	24	9	26	10	26	10
Eye diameter	20	8	21	8	23	9



1, *Maculocoetus suttoni*, n.g. et sp.—2, *Gymnothorax dakini*, n. sp.
3, *Gymnothorax garsiae*, n. sp.—4, *Teuthis fuliginosus*.

Colour in formalin dark blue-grey above, merging into white below. Dorsal fin with large black spot spread over about the fourth to the ninth rays. Caudal grey, ventrals white, not conspicuously marked. Upper pectoral rays greyish above, colourless below, lower pectoral rays colourless. Membrane of pectoral with large dark spots which are more numerous towards distal region of fin. These spots are very characteristic. Teeth on jaws very small. Palate toothless.

Description based on the holotype (Aust. Museum Reg. No. IA.6996), 260 mm. standard length. Named in honour of Professor Harvey Sutton, of the School of Tropical Medicine, Sydney University.

Ocean Id. (Waite); Nauru (Dakin). Three specimens, Nos. IA.6996 and IA.7142–3.

Family Holocenthridae.

Genus Holocenthrus Scopoli, 1777.

18. Holocenthrus erythraeus Günther. Iu n Anubwumin; Squirrel Fish.
Holocentrus erythroeus Waite.—*H. erythraeus* Fowler.
Ocean I. (Waite). Nauru (Dakin; IA.7127–9. Three specimens).

Genus Myripristis Cuvier, 1827.

19. Myripristis murdjan (Bonnaterre). Iu n Anubwumin; Squirrel Fish.
Nauru (Dakin). IA.7130–1. Two specimens.

Family Mugilidae.

Genus Ellochelon Whitley, 1930.

20. Ellochelon vaigiensis (Quoy & Gaimard). Eaeor; Mullet.
Portion of a large specimen. Nauru (Sutton). IA.7145.

Family Epinephelidae.

Genus Epinephelus Bloch, 1793.

21. Epinephelus tauvina (Bonnaterre). Iwuro; Rock Cod.
One specimen with D.xi/14; A.iii/8. Interorbital less than eye-diameter. Preopercular serrae not enlarged. Mandibular teeth almost uniserial. Opercular spines equidistant. Caudal fin rounded. Colour very dark brown with spaced rusty-reddish spots. No saddle-shaped blotches. Standard length, 234 mm.
Nauru (Dakin). IA.7140.

22. Epinephelus merra Bloch. Spotted Rock Cod.
Epinephelus merra Waite.—*Serranus merra* Fowler, 1928 and 1934.
Ocean I. (Waite).

Genus Cephalopholis Bloch & Schneider, 1801.

23. Cephalopholis sonnerati (Cuvier & Valenciennes). Egabotsijij; Black Rock Cod.
Nauru (Dakin). IA.7002.

24. Cephalopholis aurantius (Cuvier & Valenciennes). Iu n Anepe; Golden Rock Cod.
Nauru (Dakin). IA.7144.

25. Cephalopholis miniatus (Bonnaterre). Iwuro or Eanit; Spotted Rock Cod.
Nauru (Dakin). IA.7003–4; 2 specimens listed as Iwuro or Eanit. IA.7139; 1 specimen listed as Iwuro.

Genus Pogonoperca Günther, 1859.

26. Pogonoperca ocellata Günther. Ekobwo-Bwija; Spotted Rock Cod.
Nauru (Dakin). IA.7005.

Family ANTHIIDAE.

Genus CHROMANTHIAS Whitley, 1935.

27. CHROMANTHIAS EXILIS Whitley. Text-fig. 2.

Chromanthias exilis Whitley, *Rec. Austr. Mus.*, xix, 4, Sept. 19, 1935, p. 233. Nauru.

Br. 4.D.xii/14; A.ii/14; P.22; V.i/5; C.15. L. lat. 19 plus 8 or 9 pores on caudal peduncle. L. tr. 2½/1/8½. Sc. 33.

Head (10·5 mm.) equal to depth of body (10·5) and length of caudal fin (10·5) and 3·6 in standard length (38). Eye (3·25) subequal to interorbital (3·5) and upper jaw (3·2) and about one-third of head.

Eye subequal to interorbital; posterior orbital margin denticulated. Maxillary short, naked, with supplemental bone. Fine teeth on jaws and palate, none on tongue. Preorbital with a row of mucus glands. Preoperculum finely denticulated posteriorly, without antrorse spines. Three to four rows of cheek-scales. Body covered with ciliated scales. Two to three scale-rows between lateral line and back. No squamulae. Dorsal fins united, without produced spines, rays long. Two anal spines. Pectoral rays divided, the upper ones longest. Ventrals behind level of pectoral base, their first rays long. Caudal forked. Colour, in alcohol, uniform reddish-brown above and silvery below. Eye dark bluish. Dorsal fins dark brown. Other fins yellowish, the anal and caudal rather infuscated. Length, 35 to 38 mm. in standard length.

Holotype and paratype in Austr. Mus. Regd. no. I.6681. The holotype is now figured for the first time.

Genus PSEUDANTHIAS Bleeker, 1873.

28. PSEUDANTHIAS PLEUROTAENIA (Bleeker).

Anthias pleurotaenia Waite; also Fowler, 1928 and 1934.

Nauru (Waite).

NAURUA, n. gen.

Orthotype, *Naurua waitei*, n. sp.

A series of small Anthiid fishes from Pleasant Island was left unnamed by Waite, regarded with considerable doubt as *Anthias*? by McCulloch (in MS.), and briefly recorded as "a small percoid fish" by Whitley in 1935. Attacking them afresh, we are now convinced that these specimens represent a new genus and species of Anthiidae. They are easily distinguished from their congeners by their elongate form, large number of scales, and numerous dorsal rays, besides many other minor characters. In fact, they might well be separated as a new subfamily, the Nauruinae.

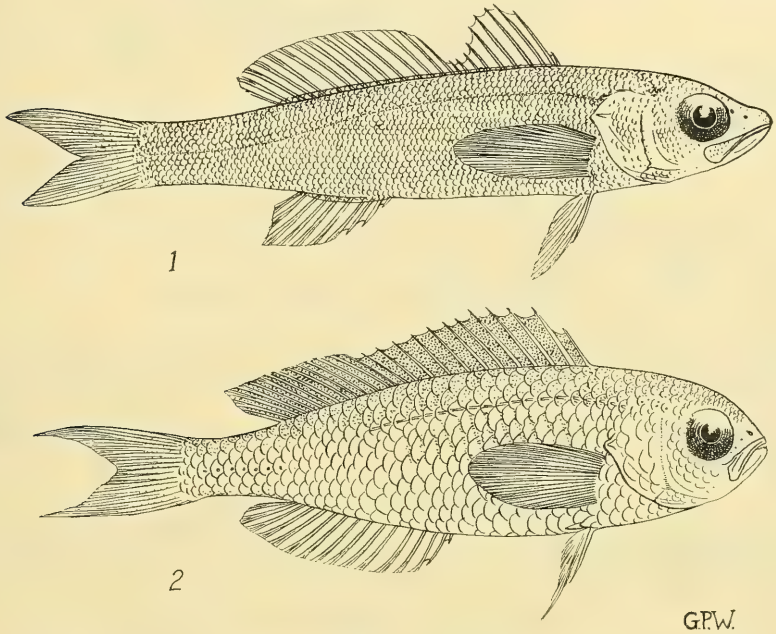
29. NAURUA WAITEI, n. sp. Text-fig. 1.

Br. 5. D.x/15; A.iii/7; P.22; V.i/5; C.13. L. lat. 72. L. tr. 4/1/19. Vertebrae 25.

Head (9·25) 3·5, depth (7) 4·6 in standard length (32·5). Eye (3) greater than interorbital (2·5). Snout (2) 4·6, length of pectoral (7) 1·3, depth of caudal peduncle (4) 2·3 in head.

Profile excavate before eyes. Snout naked, rest of head scaly. About six rows of cheek-scales. Eye large, posterior orbital margin crenulated. Interorbital convex, scaly. Preorbital very narrow. Snout overhanging mouth. Maxillary broad, scaly, just reaching to hinder half of eye; no supplemental bone. Dentition weak, on jaws and palate, consisting of a row of small hooked teeth. There is a small canine on each side of the excavated premaxillary symphysis, also a recurved canine on each side of the mandibulary symphysis, and another some way back

on each side of mandible. Tongue long, acutely pointed, edentulous. Premaxillary processes short. One well developed opercular spine before the flap. Some sharp spines (probably becoming obsolete with age) on ascending limb of preoperculum; lower limb and all other opercles entire. Some mucus pores on snout and preopercular flange. Nostrils rounded, without flaps. Brain visible through roof of head. Pseudobranchiae well developed. Gill-membranes united in front of isthmus. Gill-rakers slender, denticulated, about 2 mm. long, and about twenty in number on the lower part of the first branchial arch. Gill-filaments thick.



Text-fig. 1.—*Naurua waitei* Whitley & Colefax. Holotype from Nauru. G. P. Whitley del.
Text-fig. 2.—*Chromanthias exilis* Whitley. Holotype from Nauru. G. P. Whitley del.

Form elongate, tapering, compressed. Caudal peduncle long. Head and body covered with small strongly striated ctenoid scales, some of which form low sheaths to fins. No enlarged axillary scales. Lateral line complete, composed of single-tubed scales with their margins notched. The lateral line descends gently below the soft dorsal fin and does not form an angle on the sides. Four or five rows of scales between dorsal fin and lateral line.

Dorsal fin originating behind vertical of pectoral and ventral bases. Its first spine small, third and fourth longest, the remainder decreasing in size and united to soft dorsal. No produced spines or rays. Base of spinous dorsal fin rather less than distance from end of soft dorsal to root of tail, and considerably less than base of soft dorsal. Second anal spine thickest, third longest, yet notably shorter than anal interhaemals. Anal short, its termination in advance of that of dorsal. Pectorals on lower half of body, long, rounded, with the rays branched. Ventral fins originating behind level of pectoral base; first ventral ray long but not nearly reaching vent. Caudal forked.

General colour, after long preservation in alcohol, straw-yellowish, the fins lighter. Four patches of large dark chromatophores on vertex of head. A few speckles along back. Eye dark blue.

Described and figured from the holotype of the new species, the largest of eight specimens 1¼ to 1½ inches long, or 32·5 mm. in standard length. Australian Museum regd. no. I.6680. Holotype and paratypes.

Named in honour of the late Edgar Ravenswood Waite, well known Australian ichthyologist, and the pioneer in the study of the fishes of Nauru.

Family Duleidae.

Genus Moronopsis Gill, 1862.

30. Moronopsis taeniurus (Cuvier & Valenciennes).
Kuhlia taeniura Waite; *K. taeniura* Fowler.
Ocean I. (Waite).

Family Carangidae.

Genus Caranx Lacépède, 1802, *sensu lato*.

31. Caranx ignobilis (Bonnaterre). Trevally.
Caranx hippos Waite.—*C. ignobilis* Fowler.
Nauru (Waite). Ocean I. (Waite).

32. Caranx sexfasciatus Quoy & Gaimard. Eapwae; Trevally.
D.vii/i, 22; A.ii/i, 18. Scutes 30.
Nauru (Dakin). IA.6997.

33. Caranx melampygus Cuvier & Valenciennes. Iquidada or Emwenae; Trevally.
D.vii/i, 23; A.ii/i, 20 (21). Scutes 38.
Nauru (Dakin). IA.6998 (1 specimen labelled Emwenae); IA.7141 (1 specimen labelled Iquidada).

Genus Chorinemus Cuv. & Val., 1832.

34. Chorinemus sanctipetri Cuvier & Valenciennes. Eredeij; Leatherskin or Queenfish.
Nauru (Dakin). IA.6999.

Genus Elagatis Bennett, 1840.

35. Elagatis bipinnulatus (Quoy & Gaimard). Eoquoe; Runner.
Nauru (Dakin). One (IA.7132) labelled "Yellow Tail".

Family Lutjanidae.

Genus Lutjanus Bloch, 1790.

36. Lutjanus fulviflamma (Bonnaterre). Ituwabu; Moses Perch.
Nauru (Sutton). Three small specimens. IA.7146 and IA.7175—juvenile.

37. Lutjanus marginatus (Cuvier & Valenciennes). Iname; Hussar.
Two specimens agree well with the plate of this species in Günther's "Fische der Südsee".
There are also three very small examples, with dusky margins to dorsal fins, which are tentatively regarded as the young of this species. They were listed as Iname or Small White Fish.
Nauru (Sutton). IA.7137–8 (2 specimens); IA.7165 and 7176 (3 very small examples).

Family Malacanthidae.

Genus Malacanthus Cuvier, 1829.

38. Malacanthus hoedti Bleeker. Dobobu; Ocean Eye.
Nauru (Dakin). IA.7011.

Family Mullidae.
Genus Mulloidichthys Whitley, 1929.

39. Mulloidichthys samoensis Günther. Dauronoron; Goatfish.
Mulloides samoensis Waite.—*Mulloides samoensis* Fowler.
Nauru (Waite; Dakin, IA.7010).

Family Pempheridae.
Genus Pempheris Cuvier, 1829.

40. Pempheris otaitensis Lesson. Idibidib; Bullseye.
One specimen speared on the reef.
Nauru (Dakin). IA.7000.

Family Kyphosidae.
Genus Opisthistius Gill, 1862.

41. Opisthistius squamosus (Alleyne & Macleay). Ijibawo; Drummer.
Pachymetopon squamosum Alleyne & Macleay, Proc. Linn. Soc. N. S. Wales, Feb. 1877, p. 275, Pl. ix, fig. 1. Hall Sound, New Guinea.
Nauru (Dakin). IA.7001.

Family Chaetodontidae.
Genus Chaetodon Linné, 1758.

42. Chaetodon lunula (Lacépède). Butterfly Fish.
Two interesting larvae, in the *Tholichthys* stage, measure about 17 mm. in standard length, and correspond to the phase figured in Günther's "Fische der Südsee", Pl. 33, fig. D.
Nauru (Sutton). IA.7173.

Family Holacanthidae.
Genus Pomacanthodes Gill, 1862.

43. Pomacanthodes imperator (Bloch). Ikurubwurub; Imperial Angel Fish.
Pomacanthus imperator Fraser-Brunner, *Proc. Zool. Soc. London*, 1933, p. 556, Pl. i (refs. & synonymy).
Nauru. IA.7157.

Family Cirrhitidae.
Genus Cirrhitus Lacépède, 1803.

44. Cirrhitus pinnulatus (Bloch & Schneider). Iudud; Finger-fins.
Cirrhites maculatus Waite.—*Cirrhitus pinnulatus* Fowler, 1928 and 1934.
Nauru (Waite). Nauru (IA.7149).

Family Gempylidae.
Genus Promethichthys Gill, 1893.

45. Promethichthys prometheus (Cuvier & Valenciennes). Barracouta.
Promethichthys prometheus Waite; also Fowler, 1928 and 1934.
Ocean I. (Waite).
[A section of the posterior end of an unidentifiable Scombroid is also included in the Nauru collection (No. IA.7158): native name, Egow. Also Hambruch mentions a Nauruan 'bonito'.]

Family Ruvettidae.
Genus Ruvettus Cocco, 1833.

46. Ruvettus tydemani Weber. Eaeoquor or Te-kanebek; Palu or Oil Fish.
Ruvettus pretiosus Waite; also Fowler.

Ocean I. (Waite); Nauru (Sutton). A piece of integument, no. IA.7133, labelled *Eaeoquor*. Waite gave the native name as *Te-kanebek*. This species is known as *Palu* or *Paru* in other parts of Polynesia.

Family Istiophoridae.

Genus Istiompax Whitley, 1931.

47. Istiompax australis (Wall). Marlin Swordfish.

Tetrapturus australis Wall, *Illustr. Sydney News*, March 11, 1854, fig. Broken Bay, N. S. Wales.—*Istiompax australis* Whitley, *Austr. Zool.*, vi, 1931, p. 321, and *Rec. Austr. Mus.*, xviii, 1931, p. 148.—*Makaira australis* Fowler, *Mem. Bish. Mus.*, xi, 1934, p. 400, fig. 2 (Tahiti, etc.).—"Marlin swordfish", A. E. Ellis, *Adv. Coral Seas*, 1936, pl. opp. p. 177 (Nauru).

The Marlin Swordfish, figured from Nauru by Ellis, is tentatively identified as this species.

Family Teuthidae.

Genus Ctenochaetus Gill, 1884.

48. Ctenochaetus ctenodon (Cuvier & Valenciennes). Deiboe; Comb-toothed Surgeon Fish.

Nauru (Dakin). IA.7135–7136 (2 specimens).

Genus Teuthis Linné, 1766, *sensu lato*.

49. Teuthis fuliginosus (Lesson). Eaborobor or Deriba; Surgeon Fish. Pl. xiv, fig. 4.

One small specimen (IA.7009) is typical and is labelled *Deriba* but a larger one (IA.7134) called *Eaborobor* represents an interesting colour variant which is here described and figured. It was speared through the body.

D.vii/27; A.ii/26; P.i/15; V.i/5, C.14.

Upper profile of head weakly concave anteriorly, swollen before eyes, and thence rising evenly to over dorsal spines. Dorsal profile more arched than ventral. Head, 58 mm.; depth of body, 118; depth of caudal peduncle, 24. Eye 13 mm.; interorbital, 21; preorbital, 36. Pectoral fin, 55; ventral, 46. Eye small. Interorbital convex. Cheeks very deep, scaly. Some striae on opercles and scapulars. Five or six incisor teeth (each with four or five blunt cusps) on either side of each jaw. Body deep, compressed, covered by small imbricate ctenoid scales. Caudal peduncle with one erectile antrorse spine on each side. Dorsal and anal spines largely covered by integument. Soft portions of fins evenly rounded, not greatly elevated. Pectorals almost as long as head.

Colour, in formalin, dark chocolate-brown with milky spots on middle of sides of body posteriorly; similar small milky spots on dorsal and anal fins. Chin whitish (? blue in life). Caudal dusky. Some yellow in pectoral axil. Inner parts of ventrals yellow, otherwise smoky to dusky. No conspicuous bands or patterns. In Lesson's figure of the type (*Voy. Coquille*, Pl. xxvii, fig. 2) the colour is uniform brown with some blue on the chin.

50. Teuthis lineatus (Linné). Iwiji; Striped Surgeon Fish.

Teuthis lineatus Waite.—*Hepatus lineatus* Fowler.

Nauru—Waite; Dakin (IA.7006).

51. Teuthis troughtoni Whitley. Eweo; Banded Surgeon Fish. Fig. 3.

Teuthis troughtoni Whitley, *Rec. Austr. Mus.*, xvi, 1928, p. 233, Pl. xvi, fig. 1. Vanikoro, Santa Cruz Iss.—*Teuthis triostegus* Waite.—*Hepatus triostegus* Fowler.

This species is called *Manini* in nearly all Polynesian dialects. Our Nauruan ones are labelled Zebra fish, Eweo.

Nauru—Waite; Dakin (IA.7008, 7159, 7172) several, including juvenile stage. Ocean I. (Waite).

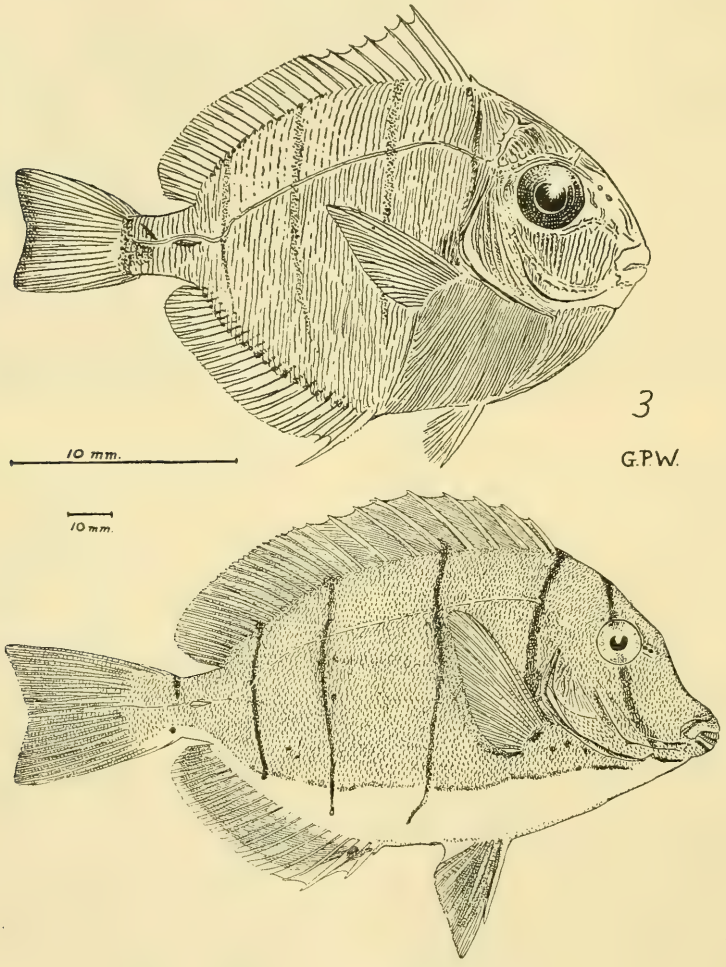
The larval and post-larval stages of the Surgeon and Unicorn fishes (Family Teuthidae) are not uncommon in warm seas. The Australian Museum has specimens from New South Wales, Queensland, the Solomon Islands, and New Hebrides. They are deep-bodied compressed little fishes an inch or so long; the sides are not scaly as in the adult but are crossed by subvertical ridges or bony striae, and there is usually a large silver area on the thorax. Except in a few cases it is impossible to identify these larval fishes with any certainty. In the past some authors have regarded them as distinct genera to which the names *Keris* (or *Ceris*), *Priodon*, *Acronurus*, and *Prionolepis* have been applied, but all these names (some of which are preoccupied) may be regarded as synonyms of *Naso*, the Unicorn fish. Jordan and Seale regarded fin-formulae as the best characters for identifying the larval Teuthidae, and, using this criterion, we can separate the larval forms which have been described into tentative subdivisions as follows. Those with five or six dorsal spines and three ventral rays are evidently young *Naso*. Those with nine dorsal spines and five ventral rays are probably *Teuthis* juveniles, but there are others which do not fall easily into either group, whilst very small larvae have not developed ventral rays at all, only a ventral spine.

Nominal Identification.	Locality.	Dorsal.	Anal.	Ventral.
Priodon annulatus Q. and G. ..	Timor.	v/29	ii/29	i/3
Priodon annularis C. and V. ..	Timor.	v/28	ii/27	i/3
Prionolepis hewittii Smith ..	South Africa.	v/29	ii/28	i/2 or 3
Naseus sp. Weber	East Indies.	v/28	ii/28	i/–
Naseus sp. Weber	East Indies.	vi/23	ii/27	—
Naseus sp. Weber	East Indies.	vi/30	ii/30	—
Keris anginosus C. and V. ..	No locality.	vii/26	iii/28	i/5
Keris anginosus Bleeker, Günth.	East Indies.	vi/26	ii/28–29	i/3
Keris amboinensis Bleeker ..	East Indies.	vi/29	ii/30	i/3
Acanthurus sp. Weber ..	East Indies.	viii/23	iii/22	i/–
Teuthis troughtoni Whitley ..	Nauru.	viii/22	iii/21	i/5
Acanthurus orbicularis C. and V.	No locality.	ix/28	iii/27	i/6 ?
Acanthurus argenteus Q. and G.	Sandwich Islands.	ix/27	iii/26	i/5
Acanthurus melanurus C. and V.	Pondicherry.	ix/26	—	—
Acanthurus melanurus Günther	Borneo.	viii/25	iii/25	—
Acanthurus coeruleus Lütken ..	Atlantic Ocean.	ix/24–28	iii/23–26	i/5
Acanthurus striatus Q. and G.*	Guam ?	ix or x/33	iii/25	i/5
Acronurus brevispinis Günther	No locality.	ix/?	iii/?	i/2
Acronurus formosus Castelnau..	Queensland.	viii/31	iii/32	i/5
Teuthis elegans Garman ..	Cocos Islands.	ix/22	iii/21	i/5
Hepatus elegans Kamohara ..	Japan.	ix/26	iii/23	i/4

* Probably young *Ctenochaetus*.

The Australian Museum specimens are withheld for future study, but in the Nauruan collections we find an interesting banded post-larva (quite different from any in the Museum) together with very slightly larger specimens which conclusively link the juvenile with the species *Teuthis troughtoni*. This Nauruan specimen is 27·5 mm. in length from snout to end of middle caudal rays, and is thus slightly less than one-fifth the length of the Vanikoro holotype, so both specimens are illustrated here (Fig. 3) to show the changes which take place

with growth. The juvenile is at the end of the larval phase because a very slightly larger specimen has metamorphosed and developed scales in place of the granular body-ridges of the larva. As tabulated above, the Nauruan larva has



Text-fig. 3.—*Teuthis troughtoni* Whitley. Juvenile specimen from Nauru and adult holotype from Vanikoro. G. P. Whitley del.

D.viii/22, A.iii/21, P.15, and V.i/5. The lateral line and mucus system are prominent and the caudal spine is developed. The main anal spine still retains the serrations and a fair degree of elongation as relics of the early larval stage, but there are no serrations on the profile of the head.

The colour is pale yellowish with dark markings (as shown in the figure) formed by brown chromatophores in the skin below the very numerous sub-vertical body-ridges. The posterior part of the head and visceral part of the thorax are dusky rather than silvery.

The following is a list of papers which we have consulted concerning larval Teuthidae:

1824. Quoy and Gaimard, Voy. *"Uranie"* et *"Physicienne"*, Zoologie, i, 1824, p. 377, Pl. lxiii.
1835. Cuvier and Valenciennes, *Hist. Nat. Poiss.*, x, 1835, pp. 166-308, Pl. ccxcv.
1852 to 1878. Bleeker, various papers as listed by Weber and de Beaufort, Fish Indo-Aust. Archipel., i, 1911.
1854. Gray, Cat. Fish coll. Gronow Brit. Museum, 1854, p. 190.
1861. Günther, Cat. Fish. Brit. Mus., iii, 1861, pp. 345 and 355.
1865. Kner, Reise der *"Novara"*, Fische, i, 1865, p. 212.
1871. Klunzinger, *Verh. Zool.-Bot. Ges. Wien*, xxi, 1871, p. 510.
1873. Castelnau, *Proc. Zool. Soc. Vict.*, ii, 1873, p. 104.
1875. Günther, *Journ. Mus. Godeffroy*, ii, 9 (Fische der Südsee, iv), Feb., 1875, pp. 108-124, and figs.
1880. Lütken, Spolia Atlantica, *Vid. Selsk. Skr.*, 5R, xii, 6, 1880, pp. 579 and 609, Pl. v.
1899. Garman, *Mem. Mus. Comp. Zool. Harvard*, xxiv, 1899, p. 70, Pl. l, fig. 2.
1906. Jordan & Seale, *Bull. U.S. Bur. Fisheries*, xxv, 1905 (1906), p. 354.
1913. Weber, Siboga Expeditie, Fische, May, 1913, p. 319, figs. 70-71.
1913. Beaufort, *Bijdragen tot de Dierkunde, Nat. Art. Mag. Amsterdam*, 1913, pp. 125-126.
1928. Fowler, *Mem. Bern. P. Bishop Mus.*, x, 1928, p. 264.
1931. Smith, *Rec. Albany Mus.*, iv, 1931, p. 145 (*Prionolepis*, a preoccupied name, given to a supposed new genus of Grammicolepidae, but actually a young *Naso*.)
1934. Delsman and Hardenberg, De Indische Zeevischen, 1934, p. 274, fig. 197.
1936. Herre, *Field Mus. Nat. Hist., Zool. Series*, xxi, 1936, p. 240.
1937. Kamohara, *Zool. Mag.* (*Japan*), xlix, 7, 1937, p. 256, fig. 1.

52. TEUTHIS GLAUCOPAREIUS (Cuvier). Deriba or Deiboe; Surgeon Fish.

Acanthurus glauco-pareius Cuvier, Règne Animal, ed. 2, ii, April, 1829, p. 224, footnote. Based on "Seb., iii, xxv, 3". East Indies. *Id.* Kittlitz, *Mus. Senckenb. Abhand.*, i, 1834, p. 193, Pl. xiii, fig. 3 (Ulea, Carolines).

Fowler (*Mem. Bish. Mus.*, x, 1928, p. 272) gives the original reference to this species as *"Harpurus glaucopareius* (Forster) Schneider, Systema ichth., Bloch, p. 212, 1801". But Bloch and Schneider do not quote that name and there is no reference earlier than Cuvier's in Sherborn's *Index Animalium*.

Nauru (Dakin). IA.7007, 7160 (several specimens). IA.7007 is labelled *Deiboe*; 7160 is labelled *Deriba*.

Genus ZEBRASOMA Swainson, 1839.

53. ZEBRASOMA FLAVESCENS (Bennett). Ekamwigogo; Deep-bodied Surgeon Fish.
One specimen of the dusky colour-form of this species.
Nauru. IA. 7155.

Genus NASO Lacépède, 1801.

54. NASO UNICORNIS (Bonnaterre). Unicorn Fish.
Naseus unicornis Waite.—*Naso unicornis* Fowler.
Nauru (Waite).

Family ZANCLIDAE.

Genus ZANCLUS Cuv. & Val., 1831.

55. ZANCLUS CANESCENS (Linné). Moorish Idol.
Nauru. IA.7156 (three specimens).

Family BOTHIDAE.

Genus BOTHUS Rafinesque, 1810.

56. BOTHUS PANTHERINUS (Rüppell). Flounder.

Rhomboidichthys pantherinus Waite.—*Platophrys pantherinus* Fowler, 1928 and 1934.

Nauru (Waite).

Family Pomacentridae.
Genus Eupomacentrus Bleeker, 1877.

57. Eupomacentrus lividus (Bloch & Schneider). Eadere; Demoiselle.
Nauru (Sutton), as Small Black Fish, *Eadere*. IA.7164 and 7178 (10 small specimens). IA.7177 is one young specimen only 13 mm. in standard length.

Genus Glyphisodon Lacépède, 1803.

58. Glyphisodon biocellatus (Quoy & Gaimard). Demoiselle.
Glyphidodon brownriggii Waite.—*Abudefduf biocellatus* Fowler.
Nauru (Waite).

Family Labridae.
Genus Thalassoma Swainson, 1839.

59. Thalassoma quadricolor (Lesson). Earamae and Eareij; Parrot Fish.
Julis quadricolor Lesson, *Dict. Class. Hist. Nat.*, xiii, January, 1828, p. 27, and *Mem. Soc. Hist. Nat. Paris*, iv, Sept., 1828, p. 400, and *Voy. Coquille*, ii, 1831, p. 139, pl. xxxv, fig. 1. Tahiti and Bora Bora.—*Thalassoma purpurea* Waite.—*Thalassoma purpureum* Fowler, 1928.—*Thalassoma quinquevittatus* Fowler, 1934.—*Thalassoma quadricolor* Whitley, *Austr. Zool.*, viii, 4, March 12, 1937, p. 225, Pl. xiv, fig. 1 (refs. & synonymy).
Nauru (Waite).
Professor Dakin obtained two specimens of this species, of which one (no. IA.7012) was called *Earamae* by the natives, and the other (IA.7013) *Eareij*.
60. Thalassoma melanochir (Bleeker). Parrot Fish.
Thalassoma melanochir Waite; also Fowler, 1928 and 1934.
Nauru (Waite).

Family Blenniidae.
Genus Nixiblennius Whitley, 1930.

Nixiblennius Whitley, *Mem. Qld. Mus.*, x, 1930, p. 20. Orthotype, *Blennius snowi* Fowler.
61. Nixiblennius snowi (Fowler). Snow's Blenny.
Blennius snowi Fowler, *Mem. Bern. P. Bishop Museum*, x, 1928, p. 431, fig. 71. Strong Island, Carolines.
From an ichthyological viewpoint, one specimen of this species from Nauru is of great interest, since it is the third known specimen, only the holotype and paratype in the Museum of Comparative Zoology, Harvard, having been recorded hitherto.
The very long ocular tentacles and high spinous dorsal fin are characteristic features. Our specimen agrees well with Fowler's account, differing only in having a small, simple tentacle over each nostril, the body-markings a trifle darker, and in lacking white spots on head and pectoral base. It is 47 mm. long and thus the largest known.
Nauru, on reef flat (Sutton). IA.7170.

Subfamily Salariinae.
Genus Salarias Cuvier, 1816.

62. Salarias caudolineatus Günther. Striped Blenny.
Nauru (Sutton). IA.7168 (1 specimen); IA.7169 (1 specimen).
63. Salarias edentulus (Bloch and Schneider). Demadara; Jumping Joey.
Nauru (Sutton), listed as Grey Fish, with native name Demadara (IA.7166–

7167); 2 specimens agreeing with Günther's figure of "*S. quadricornis*" in "Fische der Südsee", Pl. 117, fig. B, rather than with the form he figured as *S. edentulus* (fig. A).

64. Salarias periophthalmus Cuvier & Valenciennes. Blenny.
Salarias periophthalmus Waite.—*S. periophthalmus* Fowler, 1928 and 1934.
Nauru (Waite).

Genus Crenalticus Whitley, 1930.

65. Crenalticus meleagris (Cuv. & Val.). Blenny.
Salarias meleagris Waite; also Fowler.
Ocean I. (Waite).

Family Gobiidae.
Genus Bathygobius Bleeker, 1878.

66. Bathygobius fuscus (Rüppell). Ekageg; Goby.
Gobius albopunctatus Waite.—*Bathygobius fuscus* Fowler, 1928 and 1934.
Ocean I. (Waite). Nauru (Sutton). IA.7161, 7174 (several specimens).

Family Echeneidae.
Genus Leptecheneis Gill, 1864.

67. Leptecheneis naucrates (Linné). Ananit-iu; Sucking Fish.
Nauru (Dakin). IA.7015.

Family Scorpaenidae.
Subfamily Pteroinae.
Genus Pterois Schinz, 1822.

68. Pterois volitans (Linné). Eono; Butterfly Cod.
Nauru (Dakin). IA.7014.

Family Balistidae.
Genus Sufflamen Jordan, 1916.

69. Sufflamen fraenatus (Latreille). Ebwado and Ebwabwa; Trigger Fish or File Fish.
Balistes fraenatus Latreille, *Nouv. Dict. Hist. Nat.*, xxiv, March 7, 1804, p. 74. *Ex.* Lacépède, vernac. No locality.—*Sufflamen fraenatus* Whitley, *Mem. Qld. Mus.*, xi, 1937, p. 146.
Nauru (Dakin). Two specimens, of which one (IA.7016) was listed as *Ebwado*, and the other (IA.7017) *Ebwabwa*.

Genus Melichthys Swainson, 1839.

70. Melichthys vidua Richardson. Ipo; Black File Fish.
Balistes vidua Richardson, Zool. Sulphur, 1845, p. 128, Pl. lix, figs. 9–10. *Ex* Solander MS. Tahiti.
Nauru. IA.7151–2 (2 specimens).

Genus Xanthichthys Kaup, 1858.

71. Xanthichthys ringens (Linné). Ipo; File Fish.
Nauru. IA.7153.

Family Aleuteridae.
Genus Cantherhines Swainson, 1839.

72. Cantherhines pardalis (Rüppell). Ekamwigogo or Ipo; Leatherjacket.
Our specimens agree best with the figure in Günther's "Fische der Südsee".

As regards the native names, one specimen was attached to *Xanthichthys* and *Melichthys* with the label *Ipo*, and another was united with *Zebrasoma* under the name *Ekamwigogo*.

Nauru. IA.7150 and 7154 (2 specimens).

Genus Osbeckia Jordan & Evermann, 1896.

73. Osbeckia scripta (Forster). Eroreto and Erorato; Scribbled Leatherjacket.

Nauru (Dakin). Two specimens, of which one (IA.7018) was called *Eroreto* and one (IA.7019) *Erorato*, the natives apparently making some subtle distinction between phases of this variable species.

Family Tetraodontidae.

Genus Ovoides Anon., 1798.

74. Ovoides meleagris (Bloch & Schneider). Toado.

Nauru (Dakin). IA.7020–1 (2 specimens).

Native Fishing Methods.

We are indebted to Professor W. J. Dakin for the following interesting account of native fishing methods, and related topics.

"*Supply of Fish.*—Whatever the actual quantity of fish—the productivity of the Nauruan waters—there is no doubt that by the modest apparatus in use excellent catches can be easily obtained. As contrasted with the colder waters of the world, one finds that instead of large quantities of a few sorts of fish, there is a considerable diversity of species. Hambruch ('Nauru', 2 vols. Hamburg, 1914, 1915) states that the natives recognize 300 different species. Since, however, the fish often receive different names at different ages and sizes, it is likely that the number of fish species of any significance is far less than this.

There is undoubtedly a seasonal occurrence of certain fishes, and this is particularly interesting because marine conditions should be much more uniform at Nauru than in colder seas.

At the present time the supply of fish is evidently not equal to the demand in the island. This is largely due to the keenness of the Chinese workmen for fish and their ability to pay for them, coupled with what is now the lack of any necessity on the part of the Nauruans for fishing as an industry. They can obtain bully beef and other commodities with less trouble.

I did not meet any native who could have been described as an active fisherman in the sense of, say, the fisherman of Ceylon or the European fisherman.

Methods of Fishing.

Lines with temporary hooks (see Hambruch).—Two illustrations are given by this author, in which a fine line is suspended by a float. To the lower end of the line a fishbone hook or a pandanus leaf thorn is attached and baited. The fish caught by this means are, however, small, and the lines are really used more for fun (probably by the young) than for anything else. The line with float is left by itself until the float disappears.

Lines with proper fish-hooks.—There are several types of lines used by the Nauruans, and line fishing is actually the most important method of fishing employed at present. The length of line, its strength, the type of hook and bait, vary according to the fish which are to be caught and the site of the fishing. Formerly, of course, the lines were of coconut fibre, Hibiscus bast, or sea grass, but now European cords are most frequently used. The hooks, too, are of metal rather than of mother-of-pearl, coconut shell or hardwood. The Nauruans do not

prefer the metal European baited hooks for all purposes. They seem to find steel non-barbed hooks quite effective for much of their fishing and prefer these on certain occasions. The mother-of-pearl hooks figured by Hambruch (figs. 211 to 215) are no longer used and this also seems to apply to the *spinners* figured on p. 128 (figs. 216–218) which carried artificial flies of human hair, or the bristles of pigs, or dog's hair. Surface trolling, however, is employed for *bonito*. A line of 90-feet length is used for the purpose and the spinner is made of sea-bird feathers.

With line, hook, and bait, various kinds of fish can be caught according to the length of line used, and the nature of the bait employed. Hambruch states that with flying fish as bait one catches *eaeor*, *erae*, *eonubue*, *ijibauuo*, *eapai*, *emuen*, *ebo*; with long line, *irep* and *irum* (*uenion*); with a long and strong line and with two flying fish as bait, sharks (smaller species).

There are evidently many variations of the methods used, and other types of bait include the lagoon fish *Ibija*, molluscs from the reef, small reef-fish, hermit crabs and cuttle-fish. In some cases no permanent sinker is wanted and a very interesting method is then utilized for sinking the hook. The line at the hook end is wrapped several times around one or two flat stones and secured there with a temporary hitch so that a sudden jerk on the line, after the hook has been let down the required depth, releases the stones. Pieces of fish, etc., may be placed between the stones so that as they fall apart when released, a little cloud of food fragments is also released as fish 'burley'. With a line of 25 fathoms or so this method is used for 'yellow tail' (? *eaoquoi*).

With a 600-ft. line the method is employed for bonito (*itsibap* or *itibap*). A much shorter line, 30 ft., also with releasing sinkers, is used for catching *'iquori'*. For certain of the large fish which Nauruans catch at depths of 100 fathoms and over, heavy sinkers of stone or metal are used and a large hook is hidden completely by slitting a fish, and lashing it securely around the hook. The method of attaching the bait appears to be different, however, according to the species of fish to be caught.

A Nauruan trick which does not seem to be much used now was the attracting of fish—particularly sharks—by 'rattles'. One of the most common types consisted of a series of large cowrie shells on the end of a long line. By lowering these to the bottom and pulling the line up and down (a foot or so of movement), a noise was produced which was said to have attracted the sharks.

Capturing fish by lasso.—The Anabar people are reported to be expert at catching 'barracouta' with lasso. There are two methods of using lassos. One consists of line alone and is used for capture of larger sea creatures such as narwhal and the large sharks which are attracted by the scattering bait—'burley'—or by bait attached to the sling itself. The other method employs a lasso line attached to a rod about two feet in length and is used for eel capture. I was told, however, that the stick sling for eels has been practically given up.

Spearing Fish.—The capture of fish by spearing whilst the fisherman is swimming in the sea seems to be a new method which the Nauruans have learned in recent times. The fisherman wears special spectacles (imported from China) and swims slowly in the water just along the margin of the reef. He searches deliberately for his fish under water and wields the spear at what he sees under water. The method is, therefore, not the same as the more common native method practised by the Australian aborigine, who throws the spear from above the water. On the occasion of the fishing competition at Nauru, many of the competitors used

the spear in this way for the purpose of capturing fish for bait before setting out in their canoes.

The 'Eanape Fishing Apparatus'.—One of the most favoured methods of Nauruan fishing is the use of a long line attached to a small iron frame which bears several hooks. It is an attempt, therefore, towards the increase in the number of baited hooks, but there is nothing like the huge numbers on modern long lines in North Atlantic waters. The common apparatus consists of iron rods bearing wire offshoots, each of which terminates in a baited hook. There may be twenty such hooks. A variation of the method is the 'Eiror' apparatus for big fish. In this case there is no semi-rigid frame supporting the 'snoods', or hooks. At the end of the line, however, there is a series of stout wire rods each of which is linked by a comparatively loose joint with the one in front and the one behind. From each joint another rod (about one foot long) projects out at right angles and to the end of this the snood with baited hook is fastened. The scheme is essentially the same as the Eanape, except that the terminal section of the line which bears the hooks is more extended and less rigid.

Fishing Nets.—I have seen only two types of net in use and both are employed on the reef flat at high tide. One of these is to all intents and purposes a seine net, except that it is much smaller and, instead of being paid out in a semicircle from a boat, it is carried by two men who walk together, each bearing half of it upon a pole over the shoulder. Several other helpers may join them. On the appearance of a shoal of fish, the two carriers separate, letting the net fall gradually off the poles until it forms a semicircle. The fish are then surrounded, the other assistants splashing and frightening the fish to keep them within the enveloping net. The upper margin of the net is supported by floats, the bottom weighted with lead.

The other net is a conical hand-net without any rigid supports. It is held at the apex—the closed end—and the lower edge, which is about twenty feet round, is weighted at regular intervals by lead sinkers. The net has to be thrown upon a shoal of fish, leaving the hand altogether, and the movement requires skill. The whole action is really very beautiful. Both nets are very efficient in their small way, and it is doubtful whether a really large seine net could be used on the uneven coral reef flat where the water is never really deep enough for it.

The Iquan Net (*Ikuan*) and its larger type the *Egogo.*—The Ikuan net is a small bag-net supported by a metal or wooden ring (hoop) about two feet in diameter. It bears a sinker below and is sunk down at the end of a long line. A piece of bait is fastened in the net. The whole success of this rather primitive method depends upon the fisherman who is holding the line feeling the bite of the fish at the bait. He must then haul up rapidly. I was not surprised to find that this method was little used now. I have not seen a net which could be used for Egogo fishing. It was apparently large enough to require two canoes and was manipulated in the same way.

Fish Traps.—It is surprising, considering the use by natives at other islands, that fish traps are rarely employed nowadays at Nauru. Two sizes were formerly used and Hambruch states that the use of the larger one was accompanied with much ritual. The trap is illustrated by him, but I never even saw one on the island. This is strange, for he states that anything up to one thousand fish might be caught in it. The principle is just the same as that of fish traps all over the world. It was apparently lowered two hundred fathoms and left for three days. The small trap is for the capture of eels, although infrequently.

Night Fishing by Flares.—Flying fish in particular (other fish at times, e.g., garfish, may be caught in this manner) are captured in considerable numbers by setting fire to large torches made of dried coconut-palm leaves and using hand-nets to remove from the sea the fish attracted by the light.

The usual method is for two or three persons to go out on a calm and dark night with a canoe. A number of torches is carefully prepared beforehand, each about 7–9 feet long and six inches in diameter. A torch is set alight by a small slow-burning (smouldering) 'stick' of vegetable fibre. So far as my limited experience goes, the greatest rush of fish has been at the first sudden flaring out of the torch; the fish dash towards the canoe, often hitting the sides, and are lifted out rapidly by means of small hand-nets."

"Bañgos Culture": The Ibija fishery of Nauru.

Professor W. J. Dakin has given an account of bañgos culture in Nauru in the R. M. Johnston Memorial Lecture, 1934 (Science and Sea Fisheries, *Pap. Proc. Roy. Soc. Tasm.*, 1934, pp. 27–29).

EXPLANATION OF PLATE XIV.

Fig. 1.—*Maculocoetus suttoni* Whitley & Colefax. Holotype from Nauru. Miss Joyce Allan del.

Fig. 2.—*Gymnothorax dakini* Whitley & Colefax. Holotype from Nauru. Photo. Miss G. Burns.

Fig. 3.—*Gymnothorax garsiae* Whitley & Colefax. Holotype from Nauru. Photo. Miss G. Burns.

Fig. 4.—*Teuthis fuliginosus* (Lesson). Colour-variety from Nauru. Photo. Miss G. Burns.

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DESCRIPTION OF THREE NEW SPECIES OF *STIGMODERA* [BUPRESTIDAE].

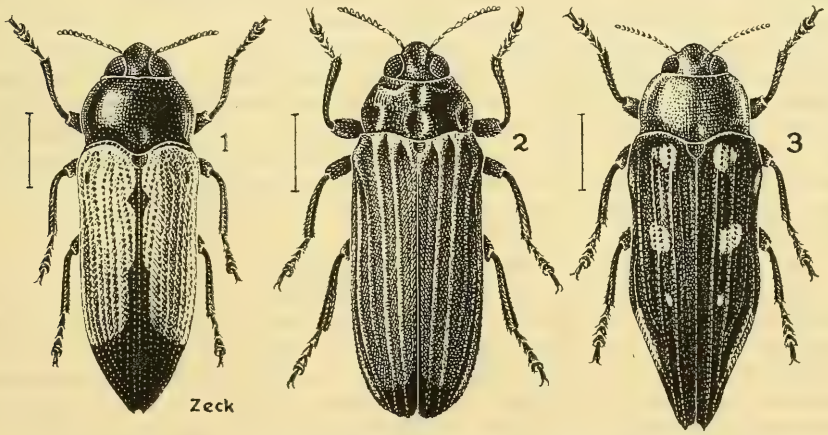
By C. Deuquet, B.Com.

(Three Text-figures.)

[Read 31st August, 1938.]

This paper contains the description of three apparently unrecorded New South Wales Stigmoderae. One of these, *S. sulfurea*, n. sp., is described from a single example. This is unfortunate, as I consider that insufficient material and lack of field experience have been the main causes of errors made in the past, chiefly by oversea writers. Of about 500 species described, some 200 are synonyms, which indicates a lack of realization of the surprising extent of their colour variability.

To illustrate how widely specimens of the same species may differ in colour, I have several examples of *S. delectabilis* Hope from the Illawarra district, which are almost entirely black, having only four very small yellow spots on the elytra



Figs. 1-3.
1, *Stigmodera (Castiarina) sulfurea*, n. sp.—2, *Stigmodera (Castiarina) sexcavata*, n. sp.—3, *Stigmodera (Castiarina) astridae*, n. sp.

and a narrow red line on the post-medial margin, while Victorian specimens are red with two black fasciae and a black preapical spot. Others, from the New England district, are yellow with two green fasciae and green preapical mark, without any red margin. A fourth variety (doubtfully distinct), *S. septemguttata* Waterh., has the fasciae replaced by diamond-shaped, unconnected markings.

Too much importance should not be attached to the coloration and markings. Collecting year after year in widely separated places gives a knowledge of these variations that could probably not be acquired otherwise.

STIGMODERA (CASTIARINA) SULFUREA, n. sp. Fig. 1.

Dimensions: 10 × 3 mm. Elongate, much attenuate at both extremities, especially at the apex. Head and pronotum dark blue; clypeus, antennae, legs and scutellum dark green. Elytra testaceous, underside, suture and wide apical mark blue-black.

Head finely punctate, lightly furrowed longitudinally, this depression slightly iridescent. Pronotum convex, widest at middle, sides well rounded. Scutellum large, cordiform, depressed and iridescent. Elytra elongate, rounded at base; on each shoulder a slight fovea extending to the humeral spot. All intervals convex and finely punctate. Apices finely bispinose, the exterior spine the more prominent, the inner one very short. Suture depressed, the blue line extending to the scutellum, enlarged a little below the latter in a small diamond-shaped spot and gradually widening to a straight apical mark 2 mm. long and covering a shade less than one-fourth of the elytra.

Underside shiny, slightly pilose, finely punctate.

Hab.—Blakebrook near Lismore, N.S.W.

A pretty and distinct species of which I only captured one ♂. In form it is near *S. wilsoni* Saund., though smaller and more acuminate at apex; in markings and colour it resembles *S. fossoria* Carter. Holotype in Coll. Deuquet.

STIGMODERA (CASTIARINA) SEXCAVATA, n. sp. Fig. 2.

Dimensions: 10 × 3½ to 4 mm. Elongate, narrow. Head, pronotum and scutellum bronzy-black; antennae, legs and tarsi bluish-black; elytra brick-red; posterior half of suture only and small straight apical mark black, covering narrowly the extreme apex. Underside blue-black.

Head deeply excavate in the centre, finely punctate. Pronotum punctate, bisinuate at base, surface uneven with six deep foveae, three at the apex and three at base. The two large and rounded central foveae separated by a smaller and narrower ridge than the ridges between the external foveae. Scutellum cordiform and deeply depressed. Elytra with fine seriate punctures as wide as prothorax at base and only slightly wider at shoulders and past the middle; prominently costate, apices sub-truncate. The apical spines only faintly discernible, slightly more in the ♂ than in the ♀.

Hab.—Armidale, N.S.W. Eight examples: 4 ♂, 4 ♀.

This species belongs to the *erythroptera* Group. It has only a restricted habitat while *S. impressicollis* Macl., which it resembles much, is common in the same district. It is also a close ally of *S. latipes* Cart., and to a lesser extent of *S. laevinotata* Cart. The last, however, is of larger size, has no pronounced depression on pronotum and has bidentate apices. *S. latipes* is also larger, with broader legs and tarsi, spinose apex, a smaller apical mark, only four foveae on the pronotum and the black line of the suture extends to the base of the elytra.

From *S. impressicollis* it is differentiated as follows:

S. impressicollis Macl.	*S. sexcavata*, n. sp.
Prothorax larger.	Prothorax shorter and narrower.
Elytra darker red.	Elytra brighter red.
4 foveae on pronotum and less prominent ridges.	6 foveae on pronotum.
Black suture starts at scutellum but does not reach extreme apex.	Only posterior half of suture and extreme apical mark black.
Has well defined apical dentation.	Subtruncate apices.

Type and other paratypes in Coll. Deuquet. One paratype each to British Museum, Macleay Museum, and National Museum, Melbourne.

STIGMODERA (CASTIARINA) ASTRIDAE, n. sp. Fig. 3.

Dimensions: 9 × 3 mm. Narrow and elongate, sharply acuminate at apex. Head, pronotum, metallic-green, very faintly punctate. Legs and antennae purplish-blue, underside green, slightly punctate and pilose. Elytra very shiny, dark purplish-green, each with three yellow, elliptical spots, a basal, not quite reaching the margin, a medial a little larger, and a faint but distinct preapical dot; also with two blood-red, marginal marks subhumeral and preapical, the latter being the longer and wider. The basal spot and the preapical dot, unconnected with the red marginal marks. A little below the preapical dot the dark green of the elytra turns to a lovely purple tint.

Head medially channelled, punctate. Pronotum strongly bisinuate at base, anterior margin almost straight, two fairly deep impressions laterally near posterior angle, and at base of medial line a fairly deep oval fovea, showing prismatic reflections, the violet and purple colours predominant. Scutellum small, cordate, flat. Elytra striate-punctate; sides deeply impressed at shoulders. Apices strongly acuminate, bispinose, the interior spine small, the exterior one projecting so that the apices appear almost unidentate.

Hab.—Illawarra Coastal Range, N.S.W.

This little gem, of which I only took four examples, 1 ♂, 2 ♀ and one doubtful, in eleven years, belongs to the *producta* group, and is like a diminutive *S. acuminata* Kerr., though more brilliantly coloured.

The following members of the *S. producta* group are also taken in the Illawarra Coastal Range, chiefly on Lilli-Pilli and other flowering trees: *producta, insignis, caudata, acuminata, delta* and *gentilis*. All are much darker than the Northern Rivers and Queensland specimens. With the permission, graciously granted by H. M. Leopold the 3rd, King of Belgium, I have dedicated this lovely species to H.M. the late Queen Astrid, whose noble memory is reverently cherished by all Belgians.

Type in Coll. Deuquet. One paratype each to British Museum, Macleay Museum, and Musée d'Histoire Naturelle, Brussels.

THE UPPER PALAEOZOIC ROCKS OF TASMANIA.

By A. H. Voisey, M.Se., Linnean Macleay Fellow of the Society in Geology.

(Two Text-figures.)

[Read 28th September, 1938.]

At the suggestion of Dr. A. N. Lewis, of Hobart, a visit was made to Tasmania during March and April, 1937, in order to examine critically the most important sections of Upper Palaeozoic rocks so that comparisons might be made at a later stage between them and corresponding sections on the mainland of Australia. This paper presents a reorganized account of the Upper Palaeozoic succession for Tasmania. It has been compiled after a careful field examination of many of the sections and a study of the literature.

It has been necessary to curtail any criticisms of earlier works owing to the length of this paper and in order to avoid confusion. The author does not agree with any interpretations previously put forward, and has attempted to subdivide the sequence in a manner which will permit more exact reference to the occurrences by future workers.

Unfortunately, it has been found imperative to reject the serial names used by Johnston (1888) and his successors, as there does not seem to be sufficient data available to uphold the implied correlation with the Hunter River (N.S.W.) Kamilaroi sequence. The same terminology as that used in New South Wales has been used in Tasmania up to the present time.

Owing to recent research on Kamilaroi palaeontology little reliance is placed on fossils whose ranges were once regarded as limited to certain zones within the system. Hence, in a fragmental record such as the Tasmanian one, it is rarely that the correct stratigraphical position of any bed can be ascertained. Similarly, it is difficult to determine either the positions or duration of any of the non-sequences, many of which must have occurred.

This paper will be destructive in its main theme, which is to break down the old system of nomenclature, but it is hoped that out of the ruins will arise a more satisfactory classification than that which has been used in the past.

Previous Literature.

The most comprehensive description of the Tasmanian Upper Palaeozoic rocks is that of R. M. Johnston (1888). He placed all the beds in the Carboniferous System and divided them into similar series to those occurring in the Hunter Valley, N.S.W., and gave these series exactly the same names, viz. Lower Marine Series, Greta Coal Measures, Upper Marine Series. He considered that no representatives of the Newcastle Coal Measures (N.S.W.), which he placed doubtfully in the Permian System, had been discovered in Tasmania.

Field-work in Upper Palaeozoic areas was carried on, notably by W. H. Twelvetrees (1903, 1912, 1915*a*, 1915*b*, 1918), Loftus Hills (1913, 1914, 1921), and

A. M. Reid (1919, 1922) prior to the publication in 1922 of "The Coal Resources of Tasmania" by the Tasmanian Geological Survey. In this publication all the Upper Palaeozoic beds were included in the Permo-Carboniferous System, but essentially the same subdivisions which had been adopted by Johnston were retained. In addition, an Upper Coal Measure series of Tomago or Newcastle age was introduced in order to include the Cygnet and Mount Pelion Coal Measures and some doubtful coal beds at Preolenna.

Careful geological mapping was carried on for some years by P. B. Nye, Government Geologist of Tasmania, chiefly in connection with the question of underground water and limestone resources (1921–1926).

Recently A. N. Lewis has made some notable observations, the most important being his recognition of a second glacial horizon which occurs high in the sequence. As Dr. Lewis's work on the Hobart District is not yet complete, he has kindly permitted me to incorporate some of his tentative conclusions in this paper.

Nomenclature.

There is still much disagreement among geologists as to the limits of the Permian System. Some desire to include in it all or part of the Uralian beds, while others regard it as commencing at the base of the Artinskian. In Australia, however, there is general agreement that there is a unity about all the beds from the base of the Lochinvar Glacial Stage to the base of the Triassic System. The fauna is uniform and characteristic throughout and cannot be confused in any way with that of the underlying Carboniferous System. Very few forms are common to both. The Glossopteris-Gangamopteris flora is characteristic also.

Australian geologists differ principally with regard to the nomenclature of the system. One group, supported strongly by the late W. S. Dun, A. B. Walkom and more recently by H. Raggatt and H. Fletcher (1937), has insisted on the use of the name of "Permian" for the sequence because, whatever arguments might be brought forward by extra-Australian geologists, the division between Carboniferous and Permian rocks, if placed higher in the sequence than the base of the Lochinvar Glacial Stage, would be artificial in the extreme and unsupported by palaeontological or lithological evidence.

The late Professor Sir T. W. E. David, while recognizing the unity of the Australian sequence, introduced the name "Kamilaroi" to replace "Permo-Carboniferous", and thereby avoided the necessity for committing himself with regard to the limits of the Permian and Carboniferous beds abroad.

While the introduction of a new term is not altogether desirable, it is preferable to "Permo-Carboniferous" and is a useful one until the controversy is settled. Should it be agreed to include in the Permian System all beds from the base of the Dwyka (South Africa), Talchir (India) and Lochinvar (N.S.W.) glacial beds up to the base of the Triassic System, the use of the name "Kamilaroi" will become unnecessary.

As the writer is opposed to the correlation of any part of the Kamilaroi sequence with the Carboniferous System, it was only after much deliberation than he decided to follow the more conciliatory course and use "Kamilaroi" instead of "Permian" in this paper.

Structure and Distribution.

The Kamilaroi sediments in Tasmania rest unconformably upon folded older Palaeozoic or Pre-Cambrian strata or upon granites which are intrusive into

Silurian and earlier sedimentary rocks. No Carboniferous or Devonian deposits have been found. The overlying beds consist of Triassic or Jurassic fresh-water sediments which are disconformable and separated by a hiatus of considerable duration. This interval marks the withdrawal of the Kamilaroi seas and the commencement of terrestrial conditions which prevailed throughout the Mesozoic Era.

The outcrops are well distributed throughout the Island, being found in outliers or in downfaulted blocks to the north and west. In the southern districts they outcrop round the flanks of the highlands where they are protected from erosion by dolerite sills. The dolerite was intruded into Kamilaroi, Triassic and Jurassic strata, probably at the close of the Jurassic sedimentation.

No great folding movements have affected the Upper Palaeozoic or Mesozoic rocks, but block-faulting at the close of the Tertiary Era has given to the beds dips amounting to as much as 10° or, locally, a higher angle. The dips correspond to the tilt of the surface of the elevated or depressed blocks on which they rest. In general, however, the beds are horizontal or nearly so, and such a disposition may be assumed for the purpose of stratigraphical discussion. Irregularities occur only in proximity to the major faults and close to dolerite intrusions.

The outcrops of Kamilaroi rocks are indicated on the accompanying map, which is based on the "Geological Map of Tasmania" published by the Tasmanian Department of Mines in 1928.

Stratigraphy.

Sedimentation during the Kamilaroi Period took place on a continental shelf including most of Tasmania. Under such conditions of relative stability there was little opportunity for the accumulation of great thicknesses of sediment. Field evidence points to considerable oscillations in sea-level, resulting in an intermittent deposition with constant redistribution of the more recently deposited sediments.

A number of important aspects of sedimentation were dealt with by Joseph Barrell (1917). Although his conclusions cannot be discussed here, they have particular application to the problems met with in an examination of the Tasmanian sedimentary record. This record is incomplete, as will be noted from the descriptions of the main sections which follow.

In this paper the Kamilaroi System in Tasmania is divided into stages. No definite nomenclature has been applied to these stages in the past, although several of them have been included in the "Upper Marine" or "Lower Marine" Series or "Coal Measures". As it does not appear likely that any one series is universal throughout Tasmania, and in view of the difficulties arising through attempts at correlation from one area to another, none of these stages have been grouped under any serial name. It is quite probable that some sections such as, say, those in the St. Mary's District, may contain stages which are not represented at all in the Hobart or Mersey sequences.

The Kamilaroi rocks may be discussed conveniently in four areal divisions as follows:

1. Southern Division, including i, Hobart District; ii, Maria Island; iii, Eaglehawk Neck; iv, Cape Paul Lamanon; v, sundry localities.

2. Northern Division, including i, Mersey District; ii, Lilydale and Karoola; iii, Beaconsfield; iv, Western Tiers; v, Wynyard and Preolenna.

Fig. 1.

3. Western Division, including i, Mount Pelion, Barn Bluff, Cradle Mountain, Eldon and Du Cane Ranges; ii, Henty River; iii, Central Plateau; iv, Point Hibbs.

4. Eastern Division, including i, St. Mary's District; ii, Avoca, Fingal, etc.; iii, Dalmayne; iv, Picanini Creek; v, Seymour; vi, Llandaff; vii, Mount Peter and Mount Paul.

1. SOUTHERN DIVISION.

The most complete sequence of Kamilaroi rocks in Tasmania occurs in this division. Unfortunately, no section has been found in which all of the stages are fully represented, and their relative positions have been deduced from the examination of a number of sections. The sequence given below appears to be reasonably correct, but subsequent work may demand minor alterations.

The following summary will convey some idea of the positions of the stages:

	Approximate Thickness (feet).
TRIASSIC SYSTEM.	
Hiatus and disconformity.	
KAMILAROI SYSTEM.	
(*g*) Cygnet Coal Measures. Fresh-water carbonaceous shales containing coal seams. Plant remains include *Gangamopteris spatulata, Gangamopteris obliqua, Glossopteris Browniana*, var. *praecursor, Vertebraria australis*. ..	200
(*f*) Lindisfarne Stage. Fine-grained grey siliceous mudstones weathering to a yellow colour. They are typically unfossiliferous, but in some areas contain bands of marine fossils.	700
(*e*) Woodbridge Glacial Stage. Marine calcareous sandstones and mudstones, occasionally fossiliferous and containing erratics of granite, quartzite, etc. Occasional limestone bands are present.	800
(*d*) Grange Stage. Typically fine-grained marine fossiliferous mudstones, bryozoan limestones and occasional sandstones.	400
(*c*) Porter's Hill Stage. A fresh-water development of sandstones and mudstones only found, up to the present, at Porter's Hill. Fragments of *Gangamopteris* and other plants are recorded. Here is also an abundance of a small crustacean, *Cythere tasmanica*.	50
(*b*) Granton Stage. Marine sandstones, grey mudstones, calcareous mudstones and dark-grey limestones containing a magnificent suite of fossils, notably *Eurydesma cordatum* and *E. hobartense*, which occur in the lower beds. Johnston (1888, 1900-01) recognized four palaeontological zones at Maria Island: (4) Crinoidal Zone, (3) Productus Zone, (2) Fenestella Zone, (1) Eurydesma Zone. These do not appear to be definitely recognizable through the Hobart District.	800
(*a*) Basal Glacial Stage. Tillites, conglomeratic mudstones with a variety of pebbles, including huge blocks of granites, schists, gneisses, slates and quartzites.	400
Hiatus and unconformity.	
OLDER PALAEOZOIC ROCKS AND GRANITES.	

The thicknesses given above are, in most cases, rough estimates only, as it is rarely that the limits of a stage can be defined. Time breaks occur, but it is impossible to determine where these are in the sequence.

i. *Hobart District.*

Kamilaroi rocks outcrop over a large part of the country between the National Park and Catamaran and also on Bruny Island. The succession is interrupted in a great many places by intrusive dolerite and also by Tertiary block-faulting. Such interruptions have made the elucidation of the sequence a most difficult matter. Dr. A. N. Lewis is engaged at present in mapping the area in detail. The following observations were made under his direction and the conclusions arrived at are largely the result of his investigations.

(g) Cygnet Coal Measures.

These beds outcrop on Bruny Island, Mount Cygnet, Southport and elsewhere in the neighbourhood of the D'Entrecasteaux Channel. Two main coal-seams and indications of others were found in the Mount Cygnet area. The upper one is from 15 inches to 3 feet thick, and the other, 20 feet lower, is about 1 foot thick. *Gangamopteris spatulata, Gangamopteris obliqua, Glossopteris Browniana* var. *praecursor*, and *Vertebraria australis* have been recorded from the locality.

Johnston (1888) described sections of these rocks at Adventure Bay and Ida Bay on Bruny Island. Here they overlie beds which appear to belong to the Lindisfarne Stage, beneath which is the Woodbridge Glacial Stage. He correlated them with the Cygnet Coal Measures, but, probably on account of his belief that the glacial beds were at the base of the system, placed them in the Lower Coal Measures. He recorded similar plant fossils to those noted above.

The beds associated with the coal-seams in this stage are carbonaceous shales and laminated sandstones sometimes showing ripple-marks.

(*f*) *Lindisfarne Stage.*

The characteristic rocks of this stage are grey mudstones which weather to a buff colour and are quite distinctive in appearance. They are generally unfossiliferous and are known as the "barren yellow mud-stones". Occasional bands of marine fossils do occur at Bruny Island, Eaglehawk Neck and elsewhere.

Immediately underlying Triassic sandstones near Sky Farm on Mount Faulkner, 700 feet of the typical unfossiliferous mudstones were measured. A prominent band of sandstone 15 feet thick marks the base of the stage in this locality.

It is probable that, in some areas, pre-Triassic erosion has removed the topmost beds of the Lindisfarne Stage together with the Cygnet Coal Measures if these had been developed. Such an occurrence would explain the variations in the thickness of the Lindisfarne Stage, which appears to be persistent throughout southern Tasmania at least.

(*e*) *Woodbridge Glacial Stage.*

These beds consist of calcareous sandstones and mudstones with occasional bands of bryozoan limestones. They form part of a continuous marine sequence and their limits are not always well defined. The main criterion for this glacial stage is the presence of angular fragments of quartzites, cherts, granites, porphyries, schists, etc. These glacial erratics are scattered through the calcareous sandstones and mudstones. Their irregular distribution is well shown by the rock platforms at Lindisfarne, Port Esperance and Bruny Island and by road cuttings at Little Peppermint Bay.

Glacial deposits have not been identified in all the sections examined, but this is not surprising, because the distribution of such rock-fragments is sporadic and, in their absence, the beds cannot be separated from those belonging to the underlying Grange Stage.

All the above-mentioned glacial beds had been included by Johnston (1888, etc.) and his successors in the Basal Glacial Stage on the assumption that there was only one glacial horizon in the sequence. In 1893 a drill hole sunk near the shore at South Port through shales and sandstones entered the glacial conglomerate at 500 feet and continued through pebbly sandstones with marine shells to 612 feet. This evidence that these glacial beds were not basal and the observations made at Little Peppermint Bay by Professor E. G. Hogg (1900–01) passed unnoticed until 1924, when Dr. A. N. Lewis found that marine sediments underlie a definite glacial horizon at Cape Paul Lamanon (Lewis, 1924). Following up this work, Lewis was able to demonstrate clearly (1937 and verbal communications) that all the Hobart glacial deposits occupied a high position in the sequence. This important discovery has removed many anomalies which arose out of the earlier interpretations.

(*d*) *Grange Stage.*

These beds are typically fine-grained mudstones and bryozoan limestones. They contain an abundance of marine fossils, notably brachiopods and bryozoans. The most characteristic form is *Wyndhamia dalwoodensis*, which is especially represented by beds several feet in thickness composed almost entirely of its remains. Other beds are more prolific in bryozoa or *Spirifera*.

The type locality for the stage is the Grange Quarry near Hobart. Intruding dolerite has hardened the mudstone, giving rise to a light-green cherty rock from which particularly good moulds showing the internal structure of the brachiopods may be obtained.

At Sandy Bay the base of the Grange Stage is determined by the Porter's Hill fresh-water beds, above which there is a well-marked change in the nature of the sedimentation. In other areas, however, these beds have not been recognized and the Grange Stage passes downwards into the Granton Stage without any apparent break.

(*c*) *Porter's Hill Stage.*

The beds referred to this stage outcrop at Porter's Hill near Sandy Bay, and have been given undue prominence by previous workers. They have been laid down under brackish or fresh-water conditions and are probably local in their development. The rocks are rhythmically bedded sandstones and mudstones containing fragmentary plant remains, among which *Gangamopteris* has been recognized (Johnston, 1888). A minute crustacean, *Cythere tasmanica*, is present. The beds pass downwards into fossiliferous marine strata possessing the same rhythmical characteristics. These marine rocks are included in the Granton Stage.

(*b*) *Granton Stage.*

As it is not possible at present to determine the upward limit of the Granton Stage except at Porter's Hill, it has been decided, tentatively, to fix an arbitrary division between it and the Grange Stage. The upward limit of the Granton Stage, then, may be taken as the topmost bed in the calcareous mudstone and limestone suite of rocks which are grouped under the name of the Berriedale Limestone. This is a well-marked datum horizon in the Hobart District. It is probable, but not definitely proven, that the Porter's Hill beds would occur stratigraphically slightly above this point, thus making the richly fossiliferous beds at the Grange Quarry correspond with those in the Mount Faulkner section between the Berriedale Limestone and the Lindisfarne Stage.

The most important horizon in the Granton Stage is the Berriedale Limestone, which may be traced for some miles round the Derwent River from Collinsvale, through Granton and Bridgewater. It is a fine-grained, greyish-blue rock, occurring in beds which are from 12 to 30 inches in width and separated by thin bands of calcareous shale 3 to 8 inches thick. Calcareous mudstones and shales occur above and below, and are most prolific in their fossil content. The whole calcareous unit aggregates 250 to 350 feet in thickness. Some bands of rock are composed almost entirely of the remains of bryozoa. Others are full of brachiopods and lamellibranchs.

Below this limestone are several hundred feet of sandstones and mudstones, with occasional bands of limestone. Marine fossils occur throughout, but not in such great abundance as in the upper beds. One of the lowest units in the

sequence, a thin band of lamellibranch limestone containing numerous specimens of *Eurydesma cordatum*, was found in cuttings on the Glen Lusk road not far from its junction with the Collinsvale road. The large numbers of this form present indicate that the beds form a *Eurydesma* horizon and hence occupy a low position in the Kamilaroi sequence. Faults terminate the section, and rocks stratigraphically lower than these have not been found in the vicinity of Hobart.

(*a*) *Basal Glacial Stage.*

Beds belonging to this stage do not occur above sea-level near Hobart, but they outcrop about 40 miles to the west. In the valley of the Weld River about 15 miles from its junction with the Huon, 300 feet of conglomerates overlie tillites and are followed by marine fossiliferous mudstones (Lewis, 1923). The conglomerates are coarse and regular, consisting of a hard yellowish matrix cementing together quartzite pebbles about the size of a cricket ball. These conglomerates are provisionally included in the Basal Glacial Stage, but may be a shallow-water facies in the Granton Stage.

Beneath the conglomerates is a tillite which, at the Weld River, contains a large proportion of red-granite boulders and pebbles. Further north, at Mount Mueller, these granites are absent and the rock fragments consist largely of grey quartzites, quartz, slate and mica-schist. Lewis found numerous scratched pebbles in the tillite, further demonstrating its glacial origin. The beds rest unconformably upon Cambrian quartzites.

ii. *Maria Island.*

The Kamilaroi section at Darlington was described by R. M. Johnston (1888, 1892, 1900) and is famed for its *Eurydesma* beds and glacial deposits. Lewis (verbal communications) has examined a number of other sections over the island and considers that the best occurs at Reidle Bay, seven miles south of Darlington. Here the glacial beds rest on the pre-Kamilaroi platform and are followed by fossiliferous limestones and "barren yellow mudstones". Ross Sandstone belonging to the Mesozoic Group follows the "barren yellow mudstones" at Darlington.

Pending detailed investigation, we may assume that representatives of the Lindisfarne and Woodbridge Glacial Stages overlie the combined Grange and Granton Stages.

The succession may be expressed as follows:

	Thickness (feet).
TRIASSIC SYSTEM.	
Hiatus and disconformity.	
KAMILAROI SYSTEM.	
(*c*) Lindisfarne and Woodbridge Glacial Stages	450
(*b*) Grange and Granton Stages (described by Johnston).	
4. Crinoidal Zone.	
Limestones consisting chiefly of crinoid remains in beds from 6 inches to 4 feet thick separated by thin shaly partings. Bands and masses of chalcedony occur.	320
3. Productus Zone.	
Blue limestone in beds 6 inches to 4 feet thick separated by beds of calcareous shale and mudstone, amounting probably to nearly half the bulk of the beds. Small pebbles not uncommon.	30
Shaly limestones very rich in *Spirifer* and *Productus*.	45
2. Fenestella Zone.	
Thin band of hard rock resembling tuff underlain by mudstones very rich in bryozoa.	125

	Thickness (feet).
1. Eurydesma Zone.	
Thick limestone bed almost entirely made up of shells of *Eurydesma cordatum* but containing a great deal of sand and large stones. ..	40
Calcareous shales and limestones.	36
(*a*) Basal Glacial Stage.	
Tillites, some of which Lewis (1937) suggests are land moraines; conglomerates consisting of boulders of slate, sandstone and granite cemented together by limestone; conglomeratic mudstones. .. .. More than	100
Hiatus and unconformity.	
Granite and Older Palaeozoic Quartzites.	

iii. *Eaglehawk Neck.*

From 600 to 800 feet of mudstones and sandstones belonging to the Lindisfarne Stage underlie Mesozoic Sandstones just north of Eaglehawk Neck. They contain several horizons of marine fossils. The beds pass downwards into the Woodbridge Glacial Stage, the topmost beds of which are exposed at the Blowhole and Tessellated Pavement.

iv. *Cape Paul Lamanon.*

Erosion has removed the Mesozoic beds and most of the Lindisfarne Stage. The Woodbridge Glacial Stage is well exposed in the cliff sections and on rock platforms between the Narrows and Cape Paul Lamanon. The thickness is estimated by Lewis (1924) to be at least 800 feet. Erratics of granite, quartzite, schist and slate are present, and marine fossils are scattered throughout the beds.

Peculiar structures referred to by the author (Voisey, 1934) as "arrow-head markings" occur in this stage and were observed also at Mount Wellington. No satisfactory explanation as to their origin has been put forward.

The Grange Stage consists of mudstones and limestones, some bands of which are made up almost entirely of brachiopods or bryozoa. *Spirifer tasmaniensis* is particularly common, while *Wyndhamia*, *Fenestella* and *Stenopora* zones are extraordinarily well developed.

Intrusive dolerite terminates the section.

v. *Sundry Localities.*

Kamilaroi rocks have been recorded from Port Arthur, Buckland, Copping, the Steppes and the Midlands. Most of these occurrences belong to the upper portions of the sequence, generally the Lindisfarne Stage, and outcrop beneath Mesozoic Sandstones which cap the hills.

2. NORTHERN DIVISION.

i. *Mersey District.*

Owing to the paucity of outcrops in this district, most of the information relating to the Kamilaroi succession has been obtained, of necessity, from bore cores or mine workings.

The beds consist of basal glacial conglomerates which pass upwards without any well-marked break into marine sandstones and mudstones containing numerous fossil shells. The deposition of marine sediments was interrupted in certain areas by a change to fresh-water conditions, resulting in the formation of the Mersey Coal Measures. Elsewhere the coal horizon is represented by an oil shale known as Tasmanite.

The succession may be considered in four stages as follows (in descending order):

	Thickness (feet).
KAMILAROI SYSTEM.	
(*d*) Upper Latrobe Stage.	
Marine sandstones and mudstones containing *Fenestella, Dielasma, Spirifer tasmaniensis, Eurydesma cordatum, Eurydesma hobartense* and *Keeneia twelvetreesi*. .. .. More than	1,000
(*c*) Mersey Coal Measures, or Tasmanite Stage. .. .. About	200
Mersey Coal Measures.	
Fresh-water mudstones, shales and sandstones with occasional conglomerates and two coal-seams. The lower or Mersey Seam is the more persistent and averages 18 inches in thickness. Plant fossils include: *Glossopteris Browniana* Brongn., *G. ampla* Dana, *G. indica* Schimper, *Gangamopteris angustifolia* McCoy, *G. cyclopteroides* Feistmantel, *Noeggerathiopsis Hislopi* Bunbury, *Phyllotheca australis, Cardiocarpus* sp. Thureau recorded the remains of an amphibian, probably a Labyrinthodont (Twelvetrees, 1912).	
Tasmanite Beds.	
Marine fossiliferous sandstones and mudstones with a 3-feet to 6-feet seam of tasmanite, an oil-shale containing resinous spore-cases of a supposed lycopodiaceous plant termed by Professor Newton of the British Museum *Tasmanite punctatus* (Reid, 1924, p. 36). The tasmanite is regarded as occupying approximately the same horizon as the Mersey Coal seam. Marine fossils include *Spirifer tasmaniensis, Aviculopecten sprenti, Deltopecten fittoni, Deltopecten subquinquelineatus, Cardiomorpha gryphioides, Pleurotomaria morrisiana*.	
(*b*) Lower Latrobe Stage.	
Marine conglomerates, pebbly sandstones, sandstones and mudstones containing *Fenestella plebeia, Stenopora tasmaniensis, Spirifer tasmaniensis, Pleurotomaria morrisiana* and, almost certainly, *Eurydesma cordatum*.	600
(*a*) Basal Glacial Stage.	
Conglomerates and sandstones containing angular fragments of quartzites, sandstones, granites and gneisses. Some glacial pebbles are excellently faceted and striated. No fossils recorded. .. .. About	150
Hiatus and unconformity.	
SILURIAN AND CAMBRO-ORDOVICIAN.	

A study of the sections based on bore-cores (Reid, 1924) suggests that beds belonging to the Lower Latrobe Stage in some areas overlap the Basal Glacial Stage. This is probably due to the fact that the sediments were laid down upon an uneven surface.

The presence of fresh-water beds, the Mersey Coal Measures, among marine strata does not necessarily prove a hiatus of any magnitude. The apparent contemporaneous continuity of deposition of marine sediments in adjacent tasmanite-bearing areas is some evidence against such a time-break. On the other hand, it is admitted that outcrops are so poor that, even if a disconformable relationship existed between any of the beds, its detection would be most unlikely.

In spite of the economic importance of the coal and tasmanite beds and the considerable work done on them, geological knowledge of the series as a whole is so incomplete that it is difficult to come to any definite conclusions as to the correct sequence of the various units.

ii. *Lilydale–Karoola.*

Essentially the same stages as those described for the Mersey District occur at Lilydale, Karoola and Mount Arthur. Exposures, however, are much better.

	Maximum thickness (feet).
Later beds removed by erosion.	
KAMILAROI SYSTEM.	
(*d*) Upper Latrobe Stage.	
Not visible in sections directly above the Tasmanite Stage, but recorded from the district by Nye (1924*a*). Thinly-bedded friable mudstones and shales containing small amounts of rounded pebbles and occasional marine fossils. .. .. At least	300
(*c*) Tasmanite Stage.	
Basal, fine to medium-grained sandstones with some coarser grits. Numerous remains of *Glossopteris* in some localities. The sandstones are overlain by mudstones which, at Karoola, contain a band of oil-shale or tasmanite.	150
(*b*) Lower Latrobe Stage.	
Sandstones and mudstones with a fine-grained, dark-blue limestone band several feet thick. The limestone is a *Eurydesma cordatum* zone. It contains also the foraminifera (Howchin, 1893) *Nubecularia lucifuga*, var. *stephensi*,* *Spiroloculina*? *planulata*, ?*Cornuspira involvens*, *Nodosaria* (?) *radicula*, numerous bryozoa, and the marine shells *Productus brachythaerus*, *Spirifer duodecimcostata*, *Reticularia*, *Deltopecten limaeformis*, *Stutchburia costatus*, *Merismopteria macroptera*, *Eurydesma hobartense*, *Platyschisma oculum* and *Ptychomphalina*. .. .. More than	150
(*a*) Basal Glacial Stage.	
Conglomerates passing up into sandstones and mudstones and containing erratic boulders of quartz, quartzites and slates, possibly of local origin, and granites, gneisses, schists and quartzites from distant sources. Occasional pebbles show faceting, polishing and grooving, denoting glacial origin.	100
Hiatus and unconformity.	
CAMBRO-ORDOVICIAN.	

iii. *Beaconsfield.*

Kamilaroi rocks cover a large portion of the country between the Mersey and Tamar rivers and are exposed near Beaconsfield, Winkleigh, Flowery Gully and Middle Arm Creek. The Basal Glacial and Lower Latrobe Stages are present, but neither coal nor tasmanite has been found. It is assumed that the beds above the Lower Latrobe Stage have been removed by erosion, but Nye (1924*b*) recognized the possibility of the fresh-water stage being represented by sandstones without any development of the carbonaceous deposits. Hence, it is possible that members of the Mersey Coal Measures, Tasmanite Stage or Upper Latrobe Stage will be identified later.

	Maximum thickness (feet).
KAMILAROI SYSTEM.	
(*b*) Lower Latrobe Stage.	
Highly fossiliferous mudstone with sandstone and some limestone. At Middle Arm Creek Johnston (1888) recognized two zones which were scarcely separable from one another:	
(1) Upper or Fenestella Zone, containing an abundance of *Fenestella internata*, *F. plebeia*, *Protoretepora ampla*, *Stenopora tasmaniensis*, *Dielasma sacculum*, and *Spirifer crebristria*.	
(2) Lower or Eurydesma Zone, containing the limestone bands and characterized by *Eurydesma cordatum*, *E. gigas*, and also *Dielasma sacculum*, *Productus scabriculus*, *Spirifer tasmaniensis*, *S. duodecimcostata*, *Aviculopecten sprenti*, *Deltopecten limaeformis*, *D. subquinquelineatus*, *Astartila polita*, *Pleurotomaria morrisiana* and *Platyschisma oculum*. There is little doubt that the limestone	

* Miss I. Crespin states that this is now included in the genus *Calcitornella*.

	Maximum thickness (feet).
in this zone corresponds with the limestone horizon which contains *Eurydesma cordatum* in the adjacent Lilydale District. .. .. About	700
(*a*) Basal Glacial Stage. Conglomerates consisting of numerous water-worn pebbles of hard rock types in a sandy matrix. Pebbles are generally well rounded, some show faceting but no grooving.	100

Hiatus and unconformity.

CAMBRO-ORDIVICIAN AND SILURIAN.

iv. *Western Tiers.*

Kamilaroi rocks outcrop round the northern and eastern margins of the Western Tiers and are disconformably overlain by Mesozoic sediments. Between the Tiers and the coast they are covered generally by Tertiary basalts and Recent deposits, but they outcrop on the banks of the River Meander near Cheshunt, in the Dunorlan District, Kimberley, and in the Quamby Brook near Quamby Bluff.

The Cheshunt beds contain *Productus brachythaerus, Dielasma sacculum, Spirifer tasmaniensis, Spirifer duodecimcostata, Eurydesma cordatum, Merismopteria macroptera, Deltopecten limaeformis, Platyschisma oculum* and *Pleurotomaria morrisiana* (Johnston, 1888). They probably can be assigned to the Lower Latrobe Stage.

Oil-shale at Quamby Bluff indicates the presence of the Tasmanite Stage. It is overlain by 300 feet of dark-grey mudstones, part of which might well be referred to the Upper Latrobe Stage. The topmost beds of the sequence are "barren yellow mudstones", lithologically comparable with those of the Lindisfarne Stage in the Southern Division. As the beds may be traced round the Tiers this correlation may be regarded as reasonably sound.

The section may be summarized as follows:

TRIASSIC SYSTEM.

Hiatus and disconformity.

KAMILAROI SYSTEM.
(*e*) Lindisfarne Stage.
(*d*) Upper Latrobe Stage.
(*c*) Tasmanite Stage.
(*b*) Lower Latrobe Stage.

The basal beds are not exposed and the thickness of the section has not been measured.

v. *Wynyard and Preolenna.*

This area is well known because of the wonderful development of glacial beds which have been described in detail by Professor T. W. E. David (1907). In the Preolenna District these are overlain by marine and fresh-water deposits (Hills, 1913). Exposures inland are scarce owing to the presence of thick horizontal scrub in the valleys and Tertiary basalt on the hills.

The stages into which the sequence has been divided may correspond with those in the Mersey District, but, as no reliance can be placed on a correlation between fresh-water phases, different stage names have been adopted. A section based upon that compiled by Hills (1913) follows:

Section interrupted by intrusive dolerite.	Maximum thickness (feet).
(*d*) Flowerdale Stage. (ii) Yellow to reddish-brown unfossiliferous sandstones which may possibly be Mesozoic.	550

	Maximum thickness (feet).
(i) Sandstone, pebbly sandstone and mudstone with marine bryozoa and brachiopods.	50
(*c*) Preolenna Coal Measures.	
Coarse-grained yellowish-brown sandstones between which are finer-grained rocks carrying coal-seams and carbonaceous material. Indeterminate plant remains.	140
(*b*) Inglis Stage.	
(ii) Grey marine mudstones containing *Fenestella, Spirifer tasmaniensis, Productus, Eurydesma* and *Aviculopecten.*	140
(i) Blue-grey unfossiliferous mudstone and conglomeratic mudstone. .. .. More than	300
(*a*) Wynyard Glacial Stage.	
Glacial till; conglomerates frequently containing erratics and striated boulders; thinly-bedded but minutely-laminated clay-shales, with intercalated thin flaggy sandstones and occasionally thin bands, 1 to 2 inches only, of boulder-clay. The sandstones and mudstones are, in many cases, beautifully ripple-marked. .. .. More than	1,220

Hiatus and unconformity.

SILURIAN, CAMBRO-ORDOVICIAN OR PRE-CAMBRIAN.

In the "Coal Resources of Tasmania" (Tas. Geol. Surv., 1922) a change was made in connection with the age and stratigraphical position of some of the Preolenna coal-seams. It was stated that: "In previous reports it has been impossible to decide whether these upper coal seams belong to the Permo-Carboniferous or the Trias-Jura as no fossil evidence was available. Their classification as belonging to Tomago is based on the recent discovery at Mount Pelion of an undoubted *Glossopteris* in shales associated with the coal at an exactly corresponding horizon as these upper coals at Preolenna."

The writer cannot accept this argument on the grounds that: (1) the discovery of *Glossopteris* at Mount Pelion does not indicate the age of the Preolenna beds unless adequate evidence for correlation is available; (2) in view of the fact that the stratigraphical position of the Preolenna coal-seams is uncertain, the statement that the coal at Mount Pelion is on "an exactly corresponding horizon" lacks foundation; and (3) no convincing evidence has been produced to demonstrate that the Mount Pelion Coal Measures correspond to the Tomago Series of New South Wales or, indeed, to any high horizon in the Kamilaroi System.

While there is a possibility that the reddish-brown sandstones placed at the top of the Flowerdale Stage might be Mesozoic, any associated coal-seams could belong to this group. On the other hand, it is more probable that faulting has placed the seams belonging to the Preolenna Coal Measures in anomalous positions. At all events, details of the occurrences of the seams are so vague that no definite conclusion can be reached.

3. WESTERN DIVISION.

i. *Mount Pelion, Barn Bluff, Cradle Mountain, Eldon and Du Cane Ranges.*

Kamilaroi rocks cover a large area in this district, but have not been examined in detail. In the neighbourhood of Mount Pelion and Barn Bluff the sequence may be divided into three stages. Sills of intrusive dolerite interrupt the succession.

	Thickness (feet).
KAMILAROI SYSTEM.	
(*c*) Mount Pelion Coal Measures.	
(ii) Sandstones with quartz pebbles in beds near the base. More than	300

	Thickness (feet).
(i) Sandstones and finely-laminated carbonaceous sandy shales containing three workable seams of coal. Plant remains include *Glossopteris ovata*? and *Noeggerathiopsis*. .. .. About	30
(*b*) Achilles Stage. .. .. About	700
(ii) Grey mudstones and shales weathering yellow, associated with rich marine fauna, including *Fenestella, Protoretepora ampla, Stenopora, Spirifer, Productus* and *Aviculopecten*.	
(i) Bluish-grey unfossiliferous mudstones.	
(*a*) Basal Glacial Stage. .. .. About	150
(ii) Pelionite Horizon. Developed at Barn Bluff and consisting of two feet of cannel coal known as "Pelionite" enclosed in black micaceous shale, sandstone and conglomerate.	
(i) Conglomerate and glacial till passing upwards into pebbly sandstones and mudstones.	

Hiatus and unconformity.

SILURIAN.

Although the Pelionite Horizon had been correlated with the Mersey Coal Measures (Tas. Geol. Surv., 1922), it is regarded here as just one phase of the Basal Glacial Stage. A similar carbonaceous deposit occurs in the St. Mary's District at the top of the St. Mary's Basal Stage.

No pelionite has been found at Mount Pelion itself.

Reid (1919) stated: "The southerly dip of the basin is apparent from an examination of the western slope of the Oakleigh Range; the quartz schist bedrock rises to the north and the coal measure strata between it and the overlying diabase (dolerite) become thinner and thinner in that direction until they entirely disappear."

In view of the observed fact that the dolerite has not been injected strictly parallel to the bedding of the Kamilaroi rocks, but is transgressive, intruding mudstones at Barn Bluff, sandstones at the south end of Cradle Mountain and conglomerates at the north end, the varying thickness of strata between bedrock and dolerite has little significance. Moreover, the southerly dip could be attributed to tilting of the basement rock during the Tertiary block-faulting movements.

ii. *Henty River.*

Marine and fresh-water rocks outcrop between Malanna and Strahan and along the northern side of the Henty River. Johnston (1891) correlated the marine beds with those round the base of East Pelion and Mount Pelion and the fresh-water beds with the overlying Mount Pelion coal measures.

KAMILAROI SYSTEM.

(*c*) Mount Pelion Coal Measures (?).
Hard fissile dark-grey shales with curious botryoidal concretions. Beautifully preserved plant fossils include *Glossopteris Browniana, Gangamopteris spatulata, Gangamopteris obliqua,* and *Noeggerathiopsis media.*

(*b*) Achilles Stage (?).
Fossiliferous marine mudstones and impure limestones characterized by *Fenestella internata, Fenestella plebeia, Protoretepora ampla, Stenopora tasmaniensis, Spirifer tasmaniensis, Spirifer avicula, Spirifer convoluta* and *Chaenomya etheridgei.*

There is no record of the underlying beds.

iii. *Central Plateau.*

Patches of Kamilaroi rocks occur over the Central Plateau and may be seen in all of the many gorges cutting into its flanks, e.g. the Ouse Valley at Waddamanna, and predominate everywhere below the 1,500 ft. contour (Lewis, 1932). The succession is interrupted by dolerite and little is known of the sequence.

The Lindisfarne Stage has been recognized in numerous places, such as the Steppes near Bothwell, while Johnston (1888, p. 128) recorded the presence of massive fossiliferous limestone with slaty rocks at Marlborough. Marine fossils found at the last-named locality include *Fenestella internata, Protoretepora ampla,* Crinoid stems, *Productus brachythaerus, Spirifer glaber* and *Spirifer stokesi.*

iv. *Point Hibbs.*

Loftus Hills (1914) described marine beds containing the usual Kamilaroi fossils from Point Hibbs on the West Coast. These rocks are associated with conglomeratic mudstones containing boulders of granites, porphyries and greisens, up to a foot in diameter. These sediments are intruded by dolerite and are tilted at high angles near the contact.

4. EASTERN DIVISION.

Within this division the Kamilaroi succession is remarkably consistent and correlation throughout is straightforward. It may be divided conveniently into two stages.

MESOZOIC GROUP.

Hiatus and disconformity.

KAMILAROI SYSTEM.

(*b*) Gray Stage.

(*a*) St. Mary's Basal Stage.

Hiatus and unconformity.

CAMBRO-ORDOVICIAN ROCKS OR GRANITE.

i. *St. Mary's District.*

Excellent exposures occur in the neighbourhood of the village of Gray, about three miles east of St. Mary's.

	Thickness (feet).
(*b*) Gray Stage.	
Sandstones, shales, bryozoan mudstones and light grey crinoidal limestones. Marine fossils include: *Plerophyllum cainodon, Fenestella* spp., *Protoretepora ampla, Stenopora* sp., *Stenopora tasmaniensis,* Crinoid stems, *Wyndhamia dalwoodensis, Terrakea fragile, Spirifer strzelecki, S. vespertilio, S. tasmaniensis, S. duodecimcostata, S. oviformis, S. stokesi, Martiniopsis oviformis, M. subradiata, Aviculopecten sprenti, Astartila* sp., *Ptychomphalina morrisiana.* .. .. About	250
(*a*) St. Mary's Basal Stage.	
(ii) Mount Elephant Coal Horizon. One or two coal seams in sandstones. Unidentified plant stems.	
(i) Water-sorted conglomerates of various degrees of coarseness. These pass up through coarse quartz-grits into normal quartz-sandstones. .. .. About	100

ii. *Avoca, Fingal, etc.*

Beds of similar character to those described above outcrop in various places in the Avoca, Fingal and Mount Nicholas districts (Nye, 1921–26; Tasmanian Geological Survey, 1922).

iii. *Dalmayne.*

The total thickness of the Kamilaroi System here is about 370 feet, comprising 170 feet belonging to the St. Mary's Basal Stage and 200 feet to the Gray Stage. Only 30 feet of strata intervene between the limestone unit and the overlying Mesozoic rocks (Nye, 1926).

MARINE BIOLOGICAL

iv. *Picanini Creek.*

An apparent thickness of 400 feet of limestone overlies the St. Mary's Basal Stage which rests unconformably upon slates at an altitude of 100 feet above sea-level. The limestone is probably duplicated by faulting and may be much thinner (Tas. Geol. Surv., 1922, p. 54).

v. *Seymour.*

No. 4 bore at Seymour passed through Mesozoic strata into Kamilaroi rocks. The section below the last coal-seam follows:

	Thickness. ft.	ins.	(Approx. position.) Depth. ft.	ins.
MESOZOIC GROUP.				
Hiatus and disconformity.				
KAMILAROI SYSTEM.				
(*b*) Gray Stage.				
Mudstones, no traces of coal	20	1½	385	2½
Mudstone, minute fossils	77	6½	462	9
Green sandstone with pebbles	22	10	485	7
Limestone (fossils)	9	9	495	4
Silicified limestone (?)	0	10	496	2
Hard limestone (fossils)	123	3	619	5
Blue limestone	125	10	745	3
Fine-grained sandstone	42	8½	787	11½
(*a*) St. Mary's Basal Stage.				
Shale, sandstone and conglomerate	16	8½	804	8
Shale and conglomerate	2	3	806	11
Coarse-grained sandstone, few coal markings	9	6	816	5
Very coarse sandstone, patches of conglomerate, no coal marks	20	10½	837	3½
Conglomerate and rotten granite boulders	54	11½	892	2

This makes the total thickness of the beds more than 500 feet, the St. Mary's Basal Stage making up 100 feet and the Gray Stage just over 400 feet.

vi. *Llandaff.*

Several outcrops of Kamilaroi rocks, including the limestone, occur around Llandaff. The beds are similar to those in the St. Mary's District (Twelvetrees, 1901; Tas. Geol. Surv., 1922, p. 84).

vii. *Mount Peter and Mount Paul.*

In this district the St. Mary's Basal Stage is represented by the usual conglomerates and sandstones. The limestone of the Gray Stage follows and, in the eastern part of the area, extends to the tops of the hills. It is overlain by Mesozoic grits immediately to the north-west of Mount Paul.

A specimen of *Eurydesma globosum* was found on the east side of Mount Peter.

PALAEONTOLOGY.

General Remarks.

Since Johnston described his Tasmanian fossils last century many alterations have been made in their names and classification. One important change has been made in connection with the lamellibranch called by Johnston *Pachydomus hobartensis*, which is known now as *Eurydesma hobartense*. Hence, when quoting from Johnston's work the present writer has taken the liberty of using the more modern designations.

Little use has been made of the fossils quoted by Johnston (1888) because he did not list them under localities but under serial names. This might not have been so unfortunate had he not included in his "Lower Marine Series" several collections from horizons now more satisfactorily correlated with those which he

regarded as belonging to the "Upper Marine Series", e.g., Bruny Island, Eaglehawk Neck, and Buckland. He, and others, were deceived by certain glacial beds thought to occur at the base of the "Lower Marine Series", but later proved to belong to the Woodbridge Glacial Stage much higher in the sequence. As there is little, if any, difference between the fauna of Johnston's "Upper Marine" and "Lower Marine" series he did not possess any information to make him think otherwise.

With a few exceptions, the fossils listed in this section were collected by the writer and were identified by Mr. H. O. Fletcher of the Australian Museum. While such lists are not nearly so complete as those of Johnston, they are more reliable in the light of our present knowledge. Localities, as well as the suggested stratigraphical positions, have been given and this will permit the use of these lists in the event of any further attempt to interpret the sequence. The specimens are catalogued and housed in the Australian Museum, Sydney.

With regard to the fossils, Fletcher states: "The fauna is one that is almost essentially Upper Marine in character, practically every species represented having been recorded either from the South Coast or Branxton beds of Eastern Australia. The large numbers of *Eurydesma*, however, from several of the Tasmanian localities mark those beds as being low in the Permian sequence. *Aviculopecten mitchelli* Eth. & Dun, usually considered as being typical of the Lower Marine Series, has been collected from the Upper Marine beds, so that its appearance here is of no significance. It is interesting to note that *Wyndhamia dalwoodensis* of Booker is present in the Grange Stage in beds with abundant *Fenestella*, an association similar to Branxton which is the type area of *Wyndhamia*. *Eurydesma cordatum* has recently been discovered in the Branxton beds where it is not uncommon, but *Eurydesma cordatum* var. *sacculum* Dana is still typical of the Lower Marine Series.

"The faunas of each locality where collections were made in the Tasmanian Permian are essentially the same, being characterized by an abundance of *Spirifer tasmaniensis* Morris, *Spirifer duodecimcostata* McCoy and *Fenestella*. It would appear from this that in Tasmania we could possibly be dealing with Permian beds with no great vertical extent, or a sequence laid down under conditions which did not materially alter."

It is the writer's belief that the Tasmanian upper Palaeozoic beds are scattered throughout nearly the whole time interval represented by the Kamilaroi System. That is to say that both Lower and Upper Marine beds are represented. Such a belief is based on the following points:

i. The Lower Marine age of certain beds appears to be proved by the presence of a basal glacial stage corresponding in position to the Lochinvar beds of New South Wales, the Talchir beds of India, and the Dwyka beds of South Africa and the occurrence not far above this of a *Eurydesma* horizon recognized also in New South Wales, India and South Africa.

ii. The Upper Marine age of some of the beds is indicated by Fletcher's remarks on the fauna. The lithology of these beds is consistent with an Upper Marine age as it is similar to that of the New South Wales beds.

iii. The Woodbridge Glacial Stage high in the sequence might well be correlated with the Upper Marine glacial beds of New South Wales.

While the evidence is not conclusive, there is at least some support for the view expressed by Cowper Reed (1932) and Raggatt and Fletcher (1937) that it is not possible to distinguish between beds corresponding respectively to the Lower and Upper Marine beds of New South Wales on palaeontological evidence alone. Further, as noted above, Johnston (1888), an authority on the Tasmanian fauna, mixed his own Lower and Upper Marine localities. It is impossible, therefore, to accept previous correlations based on faunal evidence.

List of Fossil Localities.

	Granton Stage.				Grange Stage.				Woodbridge Glacial Stage.			Other Stages.			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Plerophyllum cainodon De Kon.												Sp.			X
Fenestella fossula Lons. ..	X	X	X	X	X	X	X	X		X	X	X	X	X	X
F. internata Lons.	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Protoretepora ampla Lons. ..	X	X	X	X		X	X	X							X
Stenopora crinita Lons. ..	Sp.							X			X				Sp.
S. tasmaniensis Lons. ..		X	X	X	X		X	X				X	X	X	X
Crinoid stems		X	X										X	X	X
Chonetes sp.		X	X		X										
Dielasma sp. indet.		X	X		X	X	X							X	
Strophalosia clarkei Eth. ..	Cf.														
	X			Sp.		X		X							
S. gerardi King													X		
S. cf. *jukesi* Eth. fil. ..		X				X	X								
Terrakea brachythaera Sowerby		X				X						X			
T. elongata Eth. fil.		X				X									
T. fragile Dana							X					X		X	X
Wyndhamia dalwoodensis Booker		X	X				X					X			X
Spirifer convolutus Phill. ..								X		X				X	
S. duodecimcostata McCoy ..	X	X	X	X	X	X	X	X		X		X	X	X	X
S. stokesi Konig.				X											
S. strzelecki De Kon. ..		X			X										X
S. tasmaniensis Morris ..		X		X		X	X	X					X	X	X
S. vespertilio		X		X	X		X	X	X						X
Taeniothaerus subquadratus (Morris)		X													
Martiniopsis oviformis ..		X	X	X	X	X	X		X					X	X
M. subradiata Sowerby ..		X	X	X	X	X	X	X	X					X	X
M. subradiata var. *brantonensis* Eth. fil.						X								X	
Astartila sp.		X							X			X		X	X
? *Edmondia nobilissima* De Kon.				X					Sp.				Sp.		
? *Chaenomya etheridgei* De Kon.				X						X					
Myonia carinata (Morris) ..													X		
M. elongata Dana							X								
Notomya sp.				X											
Merismopteria macroptera (Morris)													X		
Modiomorpha ornatissima Johnston								X							
Stutchburia compressa (Morris)				X										X	
Eurydesma cordatum Morris ..	X			X									X	X	
E. cordatum var. *sacculum* Dana	X														
E. hobartense Johnston ..	X												X		
Deltopecten fittoni (Morris) ..	X			X											
D. leniusculus Dana							X								
D. limaeformis (Morris) ..	X	X										X	X	X	
D. subquinquelineatus (McCoy)		X			X										
Aviculopecten englehardti (Eth. & Dun)		X		X											
A. mitchelli (Eth. & Dun) ..		X					X								
A. multicostatus Fletcher ..															
A. sprenti Johnston ..		X				X	X					X		X	
A. squamuliferus (Morris) ..		X				X	X								
A. tenuicollis (Dana) ..	X														
Platyschisma oculus Sowerby				X	X	X		X	X			X		X	
Ptychomphalina morrisiana McCoy		X	X	X	X	X	X			X		X	X		X
Hyolithes sp.									X						

Correlations within Tasmania.

While it is reasonable to assume that the basal glacial beds throughout Tasmania are contemporaneous, the differences in lithology and thickness from place to place introduce a certain element of doubt. The variable thickness is in part due to the undulating surface upon which they were laid down, but at Wynyard the great thickness, exceeding 1,200 feet, can hardly be explained in this way. The whole deposit differs greatly from the glacial beds elsewhere and was thought by David (1932) to be older. However, there is no evidence available to determine this point.

Up to the present the St. Mary's Basal Stage has not shown any definite evidence of glacial origin, the beds being ordinary water-sorted quartz-pebble conglomerates and sandstones. The presence of the Mount Elephant Coal Horizon at Barn Bluff forms a link between these two areas. Reid (1919) described the Mount Pelion basal beds as tillite in part. The association of coal beds with them, as well as at St. Mary's, suggests that the basal beds in the Western and Eastern Divisions were laid down under terrestrial conditions.

For the purposes of correlation outside Tasmania the contemporaneity of all the basal glacial beds will be accepted tentatively.

The rich *Eurydesma* zone occurring slightly above the glacial beds provides a good datum horizon within Tasmania at least. It has been found in the Granton Stage at Maria Island, in the same stage on the Glen Lusk road near Berriedale, in the Lower Latrobe Stage at Lilydale, Karoola and Beaconsfield, and might be expected to occur in the Inglis Stage at Preolenna and the Achilles Stage in the Mount Pelion region.

With the exception of the Eastern Division, the lowest beds in the Kamilaroi System correspond quite well throughout the island if due allowance is made for change in facies. Difficulties arise as soon as the fresh-water beds are considered. In the Mersey District these appear to be quite low down in the sequence. Though they are not regarded as such important index fossils as they were, the occurrence of both *Eurydesma cordatum* and *Eurydesma hobartense* among the few fossils found in beds overlying the Mersey Coal Measures at least indicates a Lower Marine age for the Upper and Lower Latrobe Series and for the Mersey Coal Measures.

A study of the bore-cores (Reid, 1924) shows that the tasmanite bed approaches very close to the base of the series in some places, even though in others the sub-tasmanite beds attain a thickness of six or seven hundred feet. At Karoola the tasmanite is only a very small distance above the main *Eurydesma* horizon.

Unconvincing though the arguments cited above may seem, they carry more weight than the correlation which has been accepted in the past between the Mersey Coal Measures and the Porter's Hill Stage merely on the evidence of a few fragments of *Gangamopteris* in the latter.

Granton Stage: 1. Below Berriedale Limestone on Glen Lusk Road; 2. Berriedale Limestone at Collinsvale Lime kilns; 3. Berriedale Limestone at Granton; 4. Sandy Bay Beds below Porter's Hill stage.

Grange Stage: 5. Grange Quarry; 6. Mount Wellington just above old water reserve; 7. Mount Faulkner just below Lindisfarne Stage, near Sky Farm; 8. Cape Paul Lamanon below Woodbridge Glacial Stage.

Woodbridge Stage: 9. Lindisfarne rock platforms along Derwent Estuary; 10. Cape Paul Lamanon; 11. Eaglehawk Neck.

Lindisfarne Stage: 12. Eaglehawk Neck.

Lower Latrobe Stage: 13. Lilydale; 14. Karoola.

Gray Stage: 15. Gray.

As fresh-water horizons are quite common throughout Kamilaroi sequences, not only in Australia but in other parts of the world, they cannot always be regarded as datum horizons. It is not safe to correlate the Mersey Coal Measures with the Preolenna or Mount Pelion Coal Measures because no evidence can be produced to favour this. On the contrary, the Mersey Coal Measures are limited in geographical extent and pass into the marine beds of the Tasmanite Stage. Even the correlation of the Mersey Coal Measures with the Pelionite Horizon has been advocated (Tas. Geol. Surv., 1922). The writer is opposed to loose correlations between coal seams which happen to be the first fresh-water deposits developed in the respective sequences. It is unfortunate, too, that the palaeontological evidence is insufficient to disprove such correlations when once they have been made. All that can be done now is to point out that such correlations have been made in order to fit the various sequences into pre-conceived subdivisions, viz., Lower Marine, Greta, Upper Marine, etc. The stratigrapher may then judge whether any weight should be attached to them. The present writer prefers to assume that all the Coal Measures are on slightly different horizons.

In view of what has been stated above, there does not seem to be anything to recommend a correlation between any of the above beds and the Greta Coal Measures of New South Wales, more than seven hundred miles away.

The Gray Stage in the Eastern Division possesses only one distinctive feature which may be of use in correlating it with any other Kamilaroi sequence. This is the crinoidal limestone which may correspond with the Crinoidal Zone of the Granton Stage at Maria Island. In both cases crinoid remains are extraordinarily abundant, whereas they are comparatively rare elsewhere in Tasmania. The whole of the sequence in the Eastern Division differs considerably from that in the other divisions. It is more completely known because of bore records, good exposures, and in view of the fact that the units from the basal conglomerates which rest unconformably upon older rocks right to the base of the Mesozoic beds can be readily examined. Apart from the point mentioned above, there does not appear to be any means of telling whether the Gray Stage can be referred to the Upper Marine or Lower Marine Series of New South Wales. This is another matter which remains unsolved.

The Grange Stage has not been identified outside the Southern Division, but there it is characterized by *Wyndhamia dalwoodensis*. Like *Eurydesma cordatum*, this shell is not restricted to the stage in which it has its maximum development, but it is useful nevertheless in determining the beds belonging to this stage.

The Woodbridge Glacial Stage is an important stratigraphical horizon which enables a correlation to be made between many areas in the Southern Division. Hardly less distinctive are the "barren yellow mudstones" of the Lindisfarne Stage. These are recognizable over a large part of Tasmania from the Western Tiers to Hobart.

The Cygnet Coal Measures are the highest beds in the Kamilaroi sequence, but appear to be restricted in their development to the area south of Hobart.

The above interpretation of possible correlations differs from that which has been accepted by Tasmanian geologists up to the present time, in that the New South Wales terms have not been used.

The following list shows which of the stages defined by the writer would have been included in the Upper and Lower Marine Series, etc., by previous workers who used the New South Wales classification. The list has been compiled principally from the views expressed in the report on the coal resources of Tasmania made by the Geological Survey Staff in 1922. Allowance has been made for

information which has been obtained since the report was published. The principal addition is the Woodbridge Glacial Stage.

Upper Coal Measures: Cygnet Coal Measures; Higher Preolenna Coal Measures; Mt. Pelion Coal Measures.

Upper Marine Series: Lindisfarne Stage; Woodbridge Glacial Stage; Grange Stage; Upper Latrobe Stage; Flowerdale Stage; Achilles Stage; Gray Stage.

Lower Coal Measures: Porter's Hill Stage; Mersey Coal Measures; Tasmanite Stage; Preolenna Coal Measures; Pelionite horizon; Mount Elephant Coal Horizon.

Lower Marine Series: Granton Stage; Lower Latrobe Stage; Inglis Stage; Basal Glacial Stages; Wynyard Glacial Stage; St. Mary's Basal Stage.

The accompanying diagram (Fig. 2) shows some generalized Tasmanian Kamilaroi sections and illustrates the difficulties experienced in attempting correlations.

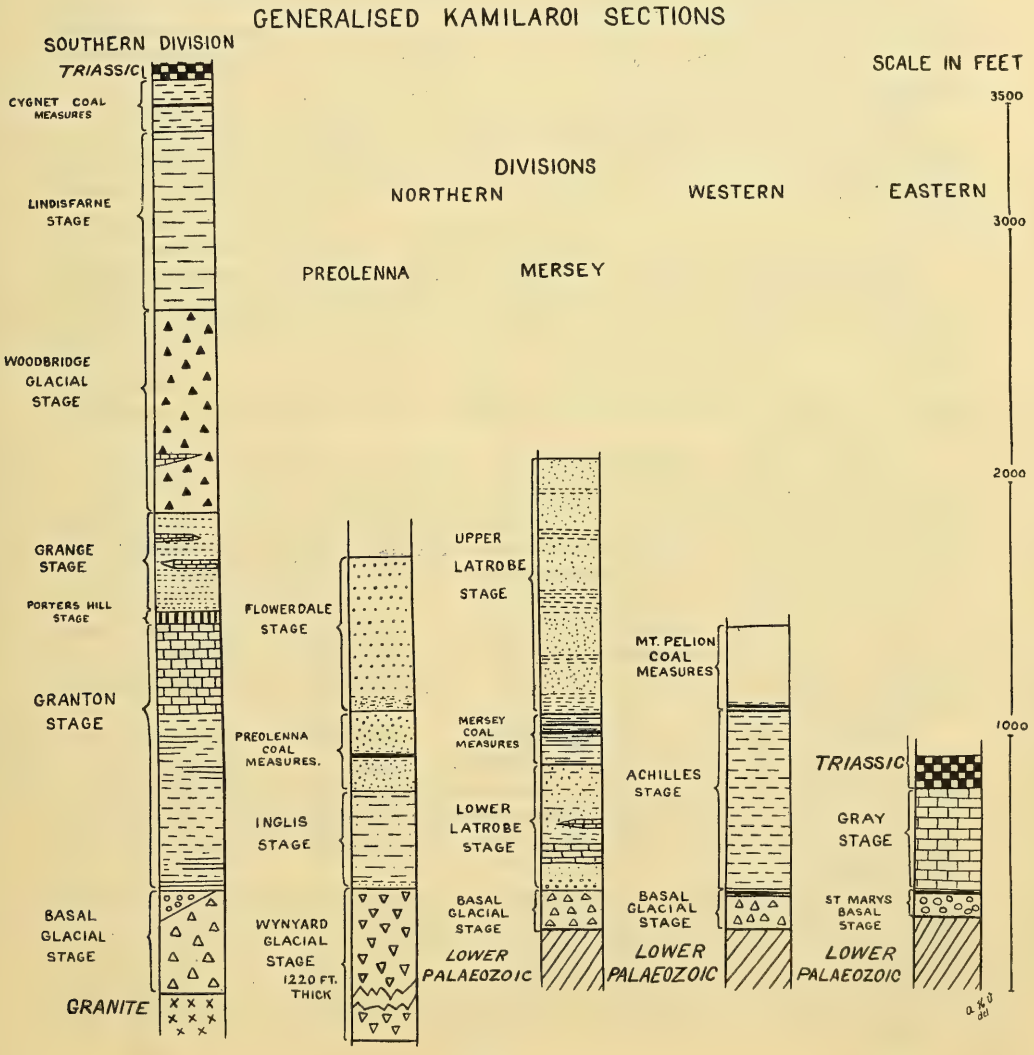


Fig. 2.

Correlations with New South Wales.

There is no doubt that all of the Upper Palaeozoic rocks of Tasmania belong to the Kamilaroi System and that they may be correlated broadly with the type sections in the Hunter River District of New South Wales.

Each sequence is characterized by a basal glacial stage followed much later by a second. Correlation between the higher stages is less certain than between the lower ones. A well-marked *Eurydesma* zone occurs low down in each section and is associated with a rich marine fauna. The similarity between the flora and fauna and their remarkable uniformity throughout the system have already been discussed. *Glossopteris* and *Gangamopteris* are the common plants, while *Fenestella, Stenopora, Spirifer tasmaniensis, Wyndhamia dalwoodensis*, the Pectens, *Ptychomphalina morrisiana* and many other marine fossils are abundant in both areas.

In making any more detailed correlation than the above, it must be remembered that the two areas are more than 700 miles apart and there is reason to believe that much of the region now known as Victoria was a land-mass during Kamilaroi times.

Most workers will concede that the Basal Glacial Stage of the Tasmanian sequence might well correspond with the Lochinvar Glacial Stage of the Lower Marine Series of New South Wales. On the other hand, it has already been pointed out that there is no certainty that the Wynyard Glacial Stage and the St. Mary's Basal Stage are contemporaneous with the Basal Glacial Stage elsewhere in Tasmania. Thus there must remain some doubt about this point.

The *Eurydesma* horizon occurs in the Granton and Lower Latrobe Stages of Tasmania and might be expected in the Inglis and Achilles Stages, so portions of each of these should correspond with the Allandale Stage of the Lower Marine Series.

In New South Wales the Greta Coal Measures follow the Lower Marine Series and in the past the Mersey Coal Measures and Porter's Hill Stage were correlated with these measures.

As noted in the preceding section, the writer cannot see any justification for the correlation of the Mersey, Preolenna and Porter's Hill Stages even within Tasmania. Hence the correlation of any of these beds with the Greta Coal Measures is unsound. Under the circumstances the dividing line between the "Lower Marine Series" and "Upper Marine Series" in Tasmania under the old scheme could not be recognized in areas where plant beds were not developed, and, as in the case of the Porter's Hill section, workers were inclined to accept any leaf-bed, no matter how indefinite, in order to provide a "Greta Series" separating the marine beds, e.g., Porter's Hill Stage, Johnston (1888), Pelionite Horizon (Tas. Geol. Surv., 1922).

The writer also is unable to separate "Lower Marine" from "Upper Marine" beds in Tasmania and has used new stage names in order to avoid the issue.

The fauna of the Grange Stage is comparable with that of the Branxton Stage of the Hunter River, and, coupled with the presence of the Woodbridge Glacial Stage immediately above, this is indicative of the Upper Marine Series of New South Wales.

In their stratigraphical position only, at the top of the succession, the Cygnet Coal Measures correspond to the Upper Coal Measures of New South Wales, but no more exact correlation can be made.

Raggatt and Fletcher (1937) have discussed the correlation of the New South Wales Kamilaroi beds with other extra-Australian areas and their views are acceptable to the writer.

Conclusion.

An attempt has been made to summarize the position with regard to the Tasmanian Upper Palaeozoic rocks, to draw attention to the weaknesses in earlier classifications, and to suggest stage names which could be used as a basis for further work.

It is hoped that this paper has done something to clarify the position with regard to this interesting area.

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NOTES ON AUSTRALIAN DIPTERA. XXXVII.

By John R. Malloch.
(*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

(Fifteen Text-figures.)

[Read 28th September, 1938.]

In this paper I present a report on the remainder of the family Chloropidae that have been in my hands for several years to complete, as far as is now possible, data on the group for Australia. Previously 107 species were known. Probably the number now listed is only a small part of those actually occurring in Australia, as the flies are small, rarely exceeding 3 millimetres in length, and some of the genera are not readily found in general collecting.

The family is divided into two subfamilies on the basis of the wing venation, Chloropinae having the costal vein discontinued at or shortly beyond the apex of the third vein, and Oscinosominae having it continued to the apex of the fourth vein. In most genera of Chloropinae there is no sensory area on the dorsal surface of the hind tibia, and in the great majority of the genera there is such an area on part of the posterodorsal surface that usually consists of a flattened or depressed elongate oval area normally furnished with dense microscopic pile, and frequently showing darker or lighter than the remainder of the tibia.

The genera in many cases are difficult to separate, rather trivial characters having been used in the past in many cases. I have attempted to discover characters that appear to be of more significance and that are more readily appreciable; the result has been that in numerous cases generic concepts have been changed. In all cases I have used the genotype as a standard for judging the relationships and have based my generic concepts almost exclusively upon the more outstanding character or characters of such genotypes. The classification herein presented will be found applicable to those genera included, wherever they occur, as, in my work, I have carefully compared species of the concepts from all faunal regions. It is, however, worth noting that a thorough revision of the family is essential to a complete understanding of all the genera and their distribution.

Subfamily Chloropinae.

Key to the Genera.

1. Mesopleura haired on posterior half or less 2
   Mesopleura bare 4
2. Hind tibia without an elongate-oval sensory area on the posterodorsal surface near middle; aristae strap-like, apical or preapical on the third antennal segment ..... *Pachylophus* Loew
   Hind tibia with an elongate-oval sensory area on the hind tibia near middle of the posterodorsal surface; aristae slender, hair-like 3
3. Frontal triangle large, elongate triangular, and glossy; outer cross-vein of the wing at much more than its own length from apex of the fifth vein, the penultimate section of third vein never longer than the penultimate section of fourth vein ..... *Chloropisca* Loew

Frontal triangle not defined, represented by a linear shiny extension from ocelli to, or nearly to, anterior margin of frons; outer cross-vein of the wing usually at about its own length from apex of fifth vein, the penultimate section of third vein always longer than the penultimate section of fourth vein ..... *Pemphigonotus* Lamb

4. Hind tibia with an elongate-oval sensory area near middle of the posterodorsal surface 5

Hind tibia without a sensory area near middle of the posterodorsal surface 7

5. Gena about one-third as high as eye; frontal triangle about two-thirds as long as frons ..... *Pseudoformosina*, n. gen.

Gena much less than one-third as high as eye 6

6. Frontal triangle continued rather widely to anterior margin of frons, bare; apical scutellar bristles situated on lower edge ..... *Formosina* Becker

Frontal triangle, if continued to anterior margin of frons, only narrowly so, and in such cases with hairs invading the surface laterally; scutellar bristles situated on upper edge ..... [1]*Chloropisca* Loew, part

7. Cross-veins of the wing exceptionally closely placed, separated by about the length of the outer one (Fig. 1) ..... *Diplotoxa* Loew

Cross-veins of the wing always separated by distinctly more than the length of the outer one 8

8. Mesonotum with a pair of well-developed dorsocentral bristles at or in front of the suture ..... *Chloropella* Malloch

Mesonotum with at most only the prescutellar pair of dorsocentral bristles 9

9. Hind femur thicker than mid pair and with either an anteroventral and posteroventral series of minute black spines on apical half or at least one series of minute spines on the apical half of the posteroventral surface, the lines on which they are situated slightly elevated; hind tibia usually more or less bent and with a slender linear ridge on the basal half or less of the ventral surface ..... *Chloromerus* Becker

Hind femur not appreciably thicker than the other pairs and without ventral armature as described above; hind tibia straight or almost so, never with a ventral linear ridge basally 10

10. Vibrissal angle sharp, slightly produced; proboscis more slender than usual and geniculated (Fig. 11) ..... *Melanum* Becker

Vibrissal angle not produced, usually rounded; proboscis stout 11

11. Third antennal segment distinctly longer than wide, angulate at upper apex; aristae black; thorax black ..... *Assuania* Becker

Third antennal segment not longer than wide nor angulate above at apex, or, if so, the aristae are white and the thorax is yellow with black markings 12

12. Thorax yellow, with black markings on dorsum; halteres yellow .. [2]*Oscinis* Latreille

Thoracic dorsum black; halteres black ..... [2]*Chloropsina* Becker

N.B.—Several genera are not included in this paper, having been previously dealt with in this series. I figure the wing of *Diplotoxa tasmaniensis* Malloch as it has not been figured by me before (Fig. 1).

Chloromerus Becker.

Ann. Mus. Nat. Hung., ix, 1911, 40; Malloch, Proc. Linn. Soc. N.S.W., xlix, 1924, 332.

I present below a key to the species of this genus known to me now, my previously published key being incomplete.

Key to the Species.

1. Hind femur at least three times as thick as mid one, minutely black dentate on apical third or more of the anteroventral and posteroventral surfaces 2

Hind femur not more than twice as thick as the mid one, with very minute black teeth on the apical third or more of the posteroventral surface only 8

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[1] This section is included to include two Australian species that may have the mesopleura bare, my material failing to show the character clearly.

[2] The distinctions between these two genera are not very clear, and at this time I have not any representative of *Chloropsina* for careful comparative study.

2. All femora quite conspicuously marked with black 3
Femora entirely yellow or only the fore and mid pairs with a faint brownish or blackish mark at middle 4
3. Femora almost entirely black, glossy; mesonotal vittae and pleural spots entirely black; prelabrum fuscous ..... *nigrifemur* Malloch
Femora yellow, with a black mark on dorsum of each at middle; mesonotal vittae largely red, central one with a pair of small black spots on posterior extremity, submedian pair each with a black mark on outer side in front of suture and the posterior half black, sublateral pair black, postsutural; sternopleural mark red, black on upper edge; prelabrum yellow ..... *maculifemur* Malloch
4. Frontal triangle yellow, only the ocellar spot black; mesopleura, sternopleura, and hypopleura each with a black mark 5
Frontal triangle yellow, with ocellar spot and lateral margins black or brown; pleura usually with five black marks ..... (*purus* Becker) 6
5. Prelabrum yellow; mesonotum with three glossy-black vittae due to the fusion of the submedian and sublateral vittae behind the suture ..... *pallidior* Becker
Prelabrum partly black; mesonotum with the usual five glossy black vittae ..... *trimaculata* Malloch
6. Mesonotal vittae largely red, only posterior extremities and sometimes the sublateral pair on outer edges presuturally black ..... *purus*, v. *varians* Malloch
Mesonotal vittae largely or entirely glossy-black 7
7. Mesonotal vittae entirely glossy-black; fore and mid femora each with a faint black mark on ventral surface at middle ..... *purus*, v. *maculifer* Malloch
Mesonotal vittae glossy-black, the central one usually reddish near anterior extremity; fore and mid femora entirely yellow ..... *purus*, v. *purus* Becker
8. Frontal triangle largely yellow, without a central sulcus and with a series of fine hairs on each side near the edges 9
Frontal triangle largely black, either with a deep wide central sulcus from ocelli to anterior extremity or without a sulcus, but in either case without a series of hairs along each side near the edges 10
9. Frontal triangle with only a black spot covering the ocelli; sternopleural spot largely or entirely red ..... *gracilis* Malloch
Frontal triangle with a central black stripe from vertex to anterior extremity; sternopleural spot glossy-black ..... *striatifrons* Becker
10. Frontal triangle not sulcate, with a black central streak from ocelli to anterior extremity; palpi largely black ..... *scutellaris* Becker
Frontal triangle with a quite deep sulcus from ocelli to anterior extremity, tapered in front, blackened in the depression; palpi yellow ..... *advena*, n. sp.

Chloromerus gracilis Malloch.

Proc. Linn. Soc. N.S.W., lii, 1927, 432.

This species agrees fairly well with the description of *Chlorops albifrons* Walker, but the antennae are not fulvous, the third segment being almost entirely black. A comparison with Walker's type, if it is still in existence, will be necessary to determine the status of the species.

Chloromerus advena, n. sp.

♂, ♀.—Head testaceous yellow, the frons darker yellow, triangle shiny black, yellowish on each side of central line; antennae orange-yellow, third segment largely blackened above and apically; aristae black; prelabrum with an elongate black streak on each side; hairs and bristles black; palpi yellow. Frons at vertex nearly half the head-width, parallel-sided, a little longer than wide, the triangle about three-fifths of the frontal width at vertex, extending to anterior margin of frons, the sulcus broad and not very deep, some of the hairs on the extreme edges on anterior fourth; surface hairs on interfrontalia numerous, longest along eyes. Vertical bristles only moderately developed, longer than the subequal ocellar and postvertical pairs. Eyes a little higher than long; gena not as high as width of third antennal segment, the latter slightly longer than wide, with the upper apical corner slightly angulate; aristae subnude. Thorax glossy-yellow, with the

usual five black vittae, usually glossy. Hairs dark, inserted in slight punctures; notopleurals 1 + 2. Pleura usually with but three black marks, those on the pteropleura and under the prothoracic spiracle usually faint or lacking. Scutellum yellow, rather broadly blackened on each side, slightly flattened on disc, the apical pair of bristles much longer than the preapical pair. Legs yellow, all femora more or less darkened centrally, the hind pair and hind tibiae broadly blackened centrally. In the female before me the legs are not blackened. Wings hyaline, veins pale brown. Third and fourth veins rather widely divergent to apices. Halteres yellow. Abdomen yellow, dull blackish-brown on dorsum except at apex of fourth and fifth tergites. Length, 3 mm.

Type, male, and allotype, Adventure Bay, Tasm., 1.i.1922 (A. Tonnoir). Paratype, Myponga, S. Australia (A. H. Elston).

The allotype has the third antennal segment paler than in the male, the prelabrum yellow, and the dark marks on the pleura reddish and not black, while the mesonotal vittae are rather evidently brownish-grey-dusted. The occurrence at the same time and place and similarity in other characters causes me to consider that it belongs with the male despite these distinctions.

Chlorops Meigen.

Illig. Mag., ii, 1803, 278; Becker, *Ann. Mus. Nat. Hung.*, ix, 1911, 53.

A careful examination of the genotype, *laeta* Meigen from the Palearctic region, discloses the fact that the mesopleura has numerous stiff hairs on the posterior half of its surface, a character that is comparatively rare in this family and has been made the basis for the distinction of certain groups as genera, the great majority of the other genera having the mesopleura bare. I have found no other species previously placed in *Chlorops* that has this character, though there may be such species as yet unknown to me. If, therefore, we make a strict interpretation of the genus on the basis of the haired mesopleura, there are no Australian species that belong to *Chlorops*. There are many poorly-defined genera in the family and a critical examination of the species available to me that would fall within *Chlorops* as generally interpreted by authors today, leads me to believe that there are several groups involved that might with good reason be considered as entitled to generic segregation from *Chlorops* in the strict sense. There are, for instance, several species that have the third antennal segment distinctly longer than wide and more or less distinctly angulate at apex above, apparently forming a connecting link between the group with the third antennal segment broadly rounded at apex and not longer than wide and *Assuania* Becker. The genotypes of *Ectecephala* Macquart, and *Parectecephala* Becker, peculiarly enough, both have the mesopleura haired behind. Judging from material in a large number of species sent to me from Europe by Dr. O. Duda, the species with bare mesopleura should be referred to *Oscinis* Latreille, though this is contrary to the attitude of Becker who, in his monograph of the European species, restricted that genus to one species that is distinguished from all others in the subfamily by the peculiar forward curvature of the second vein below the apex of first vein, these two veins being coalescent or almost so at apex of first, and the second fusing or almost so with the costal vein for a short distance beyond apex of first. I have not the species referred to.

Oscinis Latreille.

Hist. Nat. Ins. et Crust., xiv, 1804, 382.

I include the species keyed below in the genus *Oscinis*; those already described were placed in *Chlorops* by their describers.

Key to the Species.

1. Frontal triangle with a deep central sulcus from anterior ocellus to the linear apical part, or midway to anterior extremity, and a rather deep incised line along either lateral edge from vertex to near anterior extremity of the central sulcus; aristae yellow at bases, white apically; pleura with but one black spot, immediately below the prothoracic spiracle ..... *stigmatella* Becker

   Frontal triangle either centrally sulcate or without such sulcus, but if sulcate never with a deeply-incised lateral marginal line behind and the apex drawn out into a long slender point; aristae usually dark; pleura never with a single black spot, or if so it is not the stigmatal one 2

2. Frontal triangle with a well-defined central longitudinal sulcus, usually rather wide behind and extending from anterior ocellus to, or almost to, the anterior extremity; ocellar bristles not markedly longer and stronger than the post-vertical pair 3

   Frontal triangle without a distinct deep central longitudinal sulcus or groove, sometimes sulcate or furrowed on sides 8

3. Frontal triangle with numerous fine furrows on sides in addition to the central sulcus 4

   Frontal triangle without lateral furrows 5

4. Prothoracic spiracle with a deep black spot on lower margin; femora marked with black ..... *grossa* Malloch

   No black prothoracic spiracular spot; femora yellow ..... *convergens*, n. sp.

5. Antennae, palpi, and legs, entirely orange-yellow; mesonotal vittae part black and part orange-red; penultimate sections of third and fourth veins equal in length, penultimate section of fourth vein as long as ultimate section of fifth and one-third as long as its own ultimate section, the ultimate section of fifth vein not more than one-third as long as fifth vein along discal cell .... *federata*, n. sp.

   Antennae and legs partly black or fuscous; mesonotal vittae unicolorous black; penultimate section of third vein distinctly shorter than that of fourth, and about one-fourth as long as ultimate section of fourth 6

6. Mesonotal vittae overlaid with greyish-brown dust, not highly glossy; palpi yellow or brownish-yellow, sometimes faintly darkened at apices 6*a*

   Mesonotal vittae glossy-black; palpi partly black or very dark brown 7

6*a*. Frontal triangle without hairs on sides, the long hairs situated on the dull interfrontalis; mesopleura on posterior upper half with grey dust .... *blundelli*, n. sp.

   Frontal triangle with a series of stiff hairs situated in punctures along each lateral margin; mesopleura not dusted above ..... *seriata*, n. sp.

7. Femora almost entirely, and hind tibiae largely black; frontal triangle about 1·5 times as long as its width at vertex ..... *nubilipalpis* Malloch

   Femora yellow, or narrowly black centrally; frontal triangle nearly twice as long as its width at vertex ..... *sulcata* Becker

8. Frontal triangle with one or more well-defined longitudinal furrows on each side clear of the lateral edges; palpi yellow 9

   Frontal triangle smooth, without distinct longitudinal furrows 11

9. Only one furrow on each side of triangle, the apex of the latter with a short raised line; a single short hair on disc of the pteropleura in the type; third antennal segment largely yellow ..... *impressa*, n. sp.

   Several furrows on each side of the triangle; pteropleura bare 10

10. Third antennal segment and aristae black; frontal furrows very fine, mostly incomplete, not curving round and connecting in front of ocelli .... *elstoni*, n. sp.

    Third antennal segment largely yellow; aristae with basal two segments yellow, third white; frontal furrows deep and entire, the innermost one or two curving round and connecting in front of ocelli ..... *canaliculata* Becker

11. Aristae white on entire third segment, yellow or brown on basal two 12

    Aristae black or dark brown, the third segment sometimes paler basally 13

12. Base of aristae yellow; gena at middle not half as high as width of third antennal segment, the latter about 1·25 times as long as wide and quite definitely angled at apex above; frons dull laterad of the triangle; mesonotal vittae black, slightly shiny, overlaid with brown dust, five in number behind suture .... *pallidiseta* Malloch

    Base of aristae fuscous; frons shiny on at least the upper half between the triangle and eyes where it is microscopically longitudinally striate; gena as high as width of third antennal segment at middle; mesonotum with three broad glossy-black vittae, the short sublaterals behind suture fused with the submedian pair .... *variseta*, n. sp.

13. Ocellar bristles exceptionally well developed for this group, twice as long as the postverticals; mesonotal vittae slightly shiny, brownish-dusted; distance between apices of veins 3 and 4 measured round the costa about as long as the preceding section of the costa ..... *ocellaris*, n. sp.
    Ocellar bristles not, or very slightly, longer than the postvertical pair; other characters not as above in combination 14
14. Palpi largely black; femora almost entirely black 15
    Palpi yellow; femora largely or entirely so 16
15. Third antennal segment wider than long, broadly rounded at apex; fourth vein rather distinctly arched beyond the outer cross-vein; third vein nearly straight; penultimate section of fourth vein hardly shorter than ultimate section of fifth; frontal triangle with one or two short irregular impressed lines on each side posteriorly, but no definite furrows ..... *subarcuata*, n. sp.
    Third antennal segment a little longer than wide, more narrowly rounded at apex; fourth vein not arched beyond outer cross-vein; third vein evenly and rather noticeably curved forward apically; penultimate section of fourth vein not half as long as ultimate section of fifth; frontal triangle smooth behind on sides ..... *botanica*, n. sp.
16. Mesonotal vittae glossy black or dark brown, the central one sometimes partly red in middle, all without a trace of dusting 17
    Mesonotal vittae rather dull black and with greyish or brownish dusting 18
17. Mesonotal vittae entirely black, central one becoming brownish as it nears hind margin; a black spot on each humerus and basal angle of scutellum; frontal triangle bare on sides, ending in a rather long slender point, the sides concave on apical half ..... *politella*, n. sp.
    Mesonotal vittae brownish-black, the central one red except on anterior and posterior extremities, the latter about middle of disc; humeri and basal angles of scutellum with at most reddish spots; triangle yellow, ocellar spot black and a faint reddish central streak from ocelli to anterior extremity, the sides almost straight and with a series of fine hairs close to edges ..... *varivitta*, n. sp.
18. Mesonotal vittae entire, very broad, the pale ground colour almost obliterated between the vittae, where it is suffused with brown; halteres yellow, the knobs brown at apices ..... *suffusa*, n. sp.
    Mesonotal vittae not attaining the hind margin, narrower than in *suffusa*, the ground colour pale yellow; halteres yellowish-white ..... *albohalterata*, n. sp.

Oscinis stigmatella (Becker).

Ann. Mus. Nat. Hung., ix, 1911, 59.

This species is very readily separated from any other in the genus by the presence of but one deep black pleural spot, which is situated just below the prothoracic spiracle. In most cases when there is but one black mark on the pleura, it is on either the lower edge of the mesopleura or the upper part of the sternopleura. The third antennal segment is at least 1·5 times as long as wide, with the upper apex angulate, and in colour yellow, with infuscated upper and apical margin; the arista is yellow on the basal two segments and white on the third. The mesonotal vittae are five in number, rather dull black in colour because of the presence of greyish dust, and the humeri are without a distinct black spot; scutellum short and rounded, convex on disc, with black hairs and 4 to 6 marginal bristles or setulae. The fourth vein is hardly arched beyond the outer cross-vein and the third is nearly straight, ending usually nearer to apex than fourth. Ultimate section of fifth about half as long as its preceding section. Length, 3 mm.

All my material is from the vicinity of Sydney, N.S.W. The type locality is Sydney.

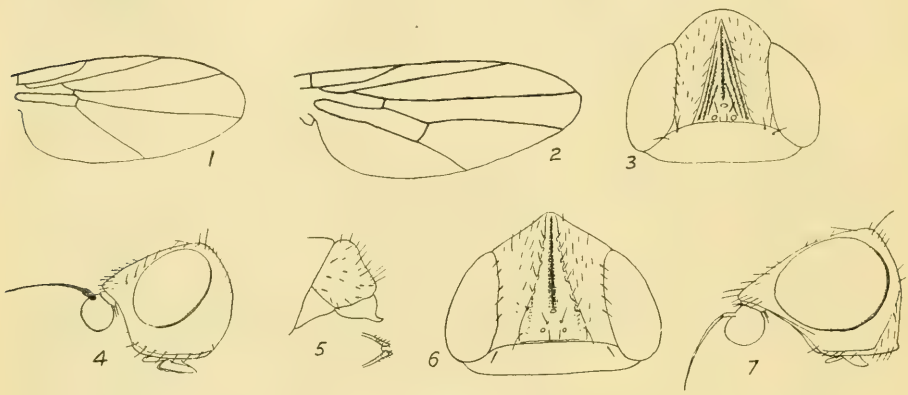
I have some doubt about the accuracy of the identification of this species from Formosa by Becker.

Oscinis grossa (Malloch). Fig. 2.

Proc. Linn. Soc. N.S.W., lvi, 1931, 70.

This species is the largest of the genus known to me from Australia, being 6·5 mm. in length. Unfortunately the specimens available lack antennae, so that it is impossible to say what the form of the third segment is, but the frontal triangle has a narrow central sulcus and on each side three converging sulci or furrows. The palpi are largely black as in *convergens*, but there are five black spots on each pleura, and the disc of the scutellum is browned in part, while the femora and at least the hind tibiae are stained with black or brown centrally. The female genital lamellae are short and broad, subtriangular, when seen from above, and black in colour. Wing as figure 2.

Tasmania.



Text-figs. 1-7.

1, *Diplotoxa tasmaniensis*, wing.—2, *Oscinis grossa*, wing.—3, *O. convergens*, frons.—4, *O. convergens*, head in profile.—5, *O. convergens*, terminalia of ♂ in profile and apex of same from below.—6, *O. federata*, frons.—7, *O. federata*, head in profile.

OSCINIS CONVERGENS, n. sp. Figs. 3–5.

♂, ♀.—Head yellow, frontal triangle, except sometimes narrowly along its edges, brownish-black, rather dull, occiput broadly brownish-black in centre except on vertical edge, third antennal segment narrowly infuscated above, arista fuscous, prelabrum yellow, palpi fuscous or blackened at apices. Frons as in Figure 3, usually three lateral furrows converging in front, but not confluent with the central sulcus, ocellar and postvertical bristles subequal, short and fine, the former proclinate and divergent; surface hairs stiff and black, quite fine, most numerous in front; frons projecting in profile (Fig. 4); eyes longer than high, subnude. Thorax yellow, but slightly shiny, mesonotum with five dull, slightly grey-dusted black vittae, the central one entire, narrowed from suture to near hind margin, widened at latter, submedian pair wide in front, tapered behind, not attaining either front or hind margin, sublateral pair extending from suture to postalar callus; surface hairs short, stiff and black, no evident punctures at their bases; humeral bristle short and fine, notopleurals 1 + 2; scutellum yellow, sometimes with a brown mark on each extreme lateral basal angle, convex, rather broadly rounded in outline, disc with a few fine black hairs, margin with four setulae, the apical pair longest and cruciate. Lower margin of mesopleura, a spot on centre of hypopleura, and a streak below upper edge of the sternopleura black, lower part of the sternopleura red. Sternopleural hairs fine and yellow; no propleural hair visible. Legs normal in form, yellow, apices of all tarsi slightly browned. Hairs short and black, pale on ventral surfaces of femora, claws black. Apical ventral spur on

mid tibia straight and about as long as diameter of the tibia. Wings greyish hyaline. Inner cross-vein distinctly proximad of apex of first vein, penultimate sections of third and fourth veins rather variable in length, the penultimate section of third always shorter than that of fourth, and the ultimate section of fifth vein always nearly half as long as its penultimate section. Abdomen orange-yellow, all tergites except the first brown at bases, the second with a darker brown spot at curve on anterior margin. Hairs fine and black. Hypopygium of male small, quite distinctive (Fig. 5), genital lamellae of female rather short and stout, tapered to apices, much as in *grossa* in general form, and fuscous in colour. Halteres yellow. Length, 3·5 mm.

Type, ♂, allotype, and 3 paratypes, Blundell's, A.C.T., 15 and 23.iii.1930 (L. F. Graham).

Oscinis federata, n. sp. Figs. 6, 7.

♀.—Head yellow, ocellar spot black, triangle brown, shiny but not highly polished, centre of occiput brown, becoming yellow above, third antennal segment hardly darkened at insertion of arista, the arista fuscous; prelabrum yellow. Frons as Figure 6; head in profile as Figure 7; frontal hairs stiff and black; ocellar bristles not visible in type, the postverticals short and fine, the central sulcus on triangle entire and deep; eyes almost nude; arista subnude. Thorax yellow, shiny; mesonotum with five shiny vittae, the central one ceasing about midway between suture and posterior margin, black on both extremities, red in middle, the submedian pair black except narrowly on suture, wide in front and tapered behind, not attaining either margin, the sublateral pair largely brown, extending from suture to postalar callus; surface hairs short, stiff, and black, rather dense, and in minute punctures on the vittae. Scutellum convex, narrowly rounded in outline, with numerous stiff discal hairs that are black in colour, and about six marginal bristles, the apical pair strongest; notopleurals 1 + 2. Pleura coloured as mesonotum, the sternopleura except on upper margin red, the propleural spot brown, a streak on lower margin of the mesopleura, a spot on the pteropleura, and another on hypopleura, black, upper margin of mesopleura browned; postnotum broadly black in centre. Sternopleural hairs fine and white; propleura with a fine black hair. Legs normal in form, entirely yellow, tarsal claws black, brown at bases. Hairs short, black except on ventral surfaces of femora. Apical ventral spur of mid tibia black, short, and straight. Wings hyaline, narrower and more pointed than usual. Third vein straight, ending as far before apex of wing as fourth does behind it; inner cross-vein almost directly below apex of first vein; for other venational characters see specific key. Halteres yellow. Abdomen yellow, tergites broadly brown, pale only at apices, the hairs dark. Genital lamellae filiform. Length, 4 mm.

Type, Molonglo R., A.C.T., 4.iv.1930 (L. F. Graham).

Oscinis blundelli, n. sp. Fig. 8.

♀.—Head yellow, frontal triangle almost glossy, brownish-yellow, dark brown to black on each side on posterior half and in the central sulcus, and black on ocellar spot, occiput with a broad central black mark. Sulcus wide above, tapered below, no lateral furrows; ocellar and postvertical bristles subequal, short and fine; surface hairs black and stiff, most numerous in front. Head in profile as Figure 8; third antennal segment a little longer than wide, subangulate at apex above, yellow, with rather broad infuscation above and apically; arista black. Eyes a little higher than long, very indistinctly haired. Palpi brownish-yellow.

Thorax rather dull testaceous yellow, with greyish dust on the entire mesonotum, upper posterior portion of the mesopleura and the upper part of the pteropleura and hypopleura. Mesonotum with five black vittae, the central one incomplete behind, the submedian pair not attaining either anterior or posterior margin, tapered behind, the sublateral pair extending from suture to postalar callus; humeri with a brown spot, notopleural suture infuscated. Surface hairs black and stiff, not inserted in punctures; notopleurals usually 1 + 2, outer postalar longer than usual. Scutellum testaceous yellow, browned on lateral basal angles, with a number of stiff black discal hairs and four marginal bristles, the apical pair the longer. Sternopleural mark black, the other four pleural spots except the stigmatal one quite large. Legs yellow, fore and hind femora and hind tibiae marked with brown or black centrally, apices of all tarsi slightly browned, tarsal claws black. Apical ventral spur of mid tibia fully as long as apical diameter of the tibia and rather noticeably curved. Wings greyish hyaline. Inner cross-vein a little proximad of apex of first vein, third and fourth veins regularly divergent from outer cross-vein to apices; penultimate section of third vein shorter than penultimate section of fourth, ultimate section of fifth vein half as long as its penultimate section; third vein ending as far before apex of wing as fourth does behind it. Halteres yellow. Abdomen yellow, tergites broadly brown, only their apices yellow, hairs black except on sides of second tergite. Genital lamellae slender and elongate. Length, 2·5 mm.

Type and 1 paratype, Blundell's, A.C.T., 7.i.1930 (A. Tonnoir).

Oscinis seriata, n. sp.

♀.—Similar in general colour and markings to *blundelli*, differing in having the palpi bright orange-yellow, not brownish-yellow, the mesonotum not so distinctly dusted, and the mesopleura without dust on the upper posterior portion. The frons and triangle are longer and narrower, with the latter having some black hairs arranged in a series of punctures along each side. The sulcus is entire and but little narrowed in front.

In nearly all other respects the two species are almost identical. Length 3 mm.

Type, Barrington Tops, 25.i.1922 (Nicholson); paratype, Fish River, N.S.W., 25.iii.1923 (Health Dept.).

Oscinis nubilipalpis (Malloch).

Proc. Linn. Soc. N.S.W., lvi, 1931, 72.

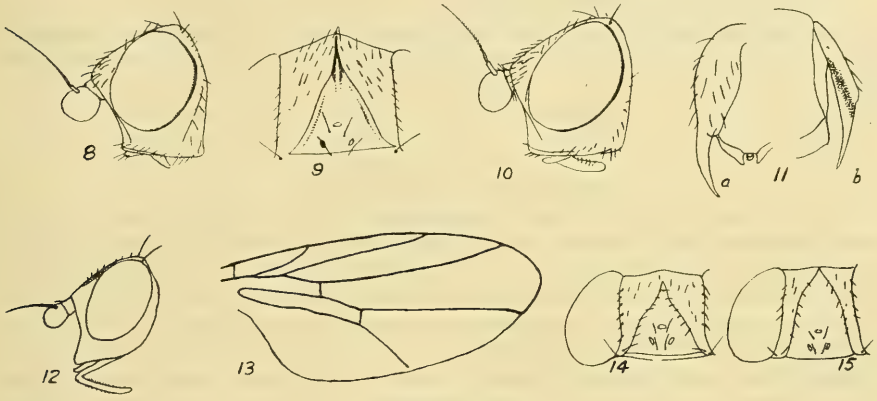
This species is quite similar in most respects to *blundelli*, differing in the lack of grey dust on the mesonotum and pleura, the glossy-black mesonotal vittae, much darker third antennal segment and palpi, and the almost entirely glossy-black femora and more extensively blackened hind tibiae. The mesonotal hairs are also much denser and situated in definite punctures; the male has the hypopygium spike-like behind in the type, and the female has the genital lamellae even more slender than does the female of *blundelli*.

Tasmania.

Oscinis impressa, n. sp. Figs. 9–10.

♂.—Head testaceous yellow, frons reddish, darkest along triangle, the latter black, almost glossy, yellowish on posterior lateral angles; occiput black, with a rather broad yellow margin along eyes; third antennal segment narrowly infuscated apically; arista fuscous on basal two segments and base of third, brownish-yellow apically; prelabrum glossy-black; palpi yellow. Frontal hairs and

bristles black, genal hairs yellow except at posterior angle. Frons as Figure 9, the triangle with a single furrow along each side from near upper posterior angle to beyond middle, and with a slight central carina on anterior half or less; surface hairs stiff, longest along eyes and triangle, and more numerous anteriorly. Profile as Figure 10; third antennal segment about as high as long, rather broadly rounded in front and almost imperceptibly angulate at apex above. Eyes subnude.



Text-figs. 8-15.

8, *Oscinis blundelli*, head in profile.—9, *O. impressa*, frons.—10. *O. impressa*, head in profile.—11, *O. elstoni*, terminalia; *a*, from behind, *b*, in profile.—12, *Melanum multisulcatum*, head in profile.—13, *M. multisulcatum*, wing.—14, *Chloropisca monticola*, frons, right side incomplete.—15, *C. sydneyensis*, frons, right side incomplete.

Thorax rather dull testaceous-yellow. Mesonotum with five dull black vittae that are overlaid with slight yellowish-brown dust, visible when seen from the side and slightly in front, the central vitta entire, widened at posterior extremity, submedian pair broad, extending from humeri to posterior margin and slightly narrowed at posterior extremities, narrowly separated from the broad sublateral vittae that extend from the suture to the postalar callosities; humeri with a small brown spot. Surface hairs black, decumbent and quite dense, situated in almost imperceptible punctures on the black vittae. A black mark on notopleural suture above the spiracle, lower part of the sternopleura, a large spot on the hypopleura and another on the pteropleura and the lower half of the mesopleura, glossy black, no black spot on the propleural spiracle. The single hair on each pteropleura may be an abnormal occurrence in this specimen and may not hold in a series of examples of the species. Scutellum short, rather narrowly rounded at apex, convex, pale yellow, with a brown mark below at each lateral basal angle, discal hairs black, stiff, margin with about six setulae, the apical pair longest and quite close together. Legs yellow, all femora and hind tibiae rather irregularly stained with black centrally, fifth tarsal segment of all legs black or fuscous. Apical ventral spur of mid tibia not longer than tibial diameter, straight. Wings greyish hyaline. First vein rather thick apically; inner cross-vein a little proximad of apex of first vein; penultimate section of third vein a little longer than penultimate section of fourth, the latter a little more than half as long as ultimate section of fifth and about one-fifth as long as its own ultimate section, the ultimate section of fifth not half as long as its preceding section. Squamae with dark margin and fringe. Halteres yellow. Abdomen rather broad, black on dorsum, the posterior lateral

angles of second and third tergites seen from above, and the apical margins of fourth and fifth tergites pale yellow. Surface hairs black; genital lamellae slender and dark. Length, 3·5 mm.

Type, Geeveston, Tasmania, Dec. 7, 1922 (A. Tonnoir).

Oscinis sulcata (Becker).

Ann. Mus. Nat. Hung., ix, 1911, 58, Tab. 1, fig. 2.

This species is a little larger than *nubilipalpis* Malloch, with the frons more protuberant in front, the triangle longer, genae higher, the sides of the scutellum less extensively blackened, and the amount of black colouring on the legs much less.

Blundell's, A.C.T., 14.iv.1931 (L. F. Graham). Type locality, Mt. Victoria, N.S.W.

Oscinis elstoni, n. sp. Fig. 11.

♂, ♀.—Head yellow, the frontal triangle and occiput except the lateral margins shiny brownish-black, antennae and aristae black, the second segment of former brownish; prelabrum brownish-black, forming two elongate backwardly-directed slender streaks. Frontal triangle nearly filling the vertex almost triangular, the sides very slightly concave near apex, the apex forming a short linear strip, the surface with 4 to 6 fine striae on each side that meet on the central line in front of ocelli; no central sulcus developed, frontal bristles weak, hairs short and fine, dark. Antennae rather small, third segment about as long as wide, narrowly rounded at apex; arista subnude. Face vertical. Gena about as high as width of third antennal segment. Eyes subnude, about as high as long, not evenly rounded. Palpi yellow.

Thorax yellow, mesonotum with 5 slightly shiny black vittae, the sublaterals postsutural, the others quite broad and covered with grey dust; humeri with a black spot. Hairs and bristles black; notopleurals 1 + 2. Scutellum yellow at base, suffused with black on disc, and black on margin, the hairs and bristles black. Pleura with 4 black spots, the stigmatal one lacking or poorly developed. Legs yellow, all femora except their extremities black, hind tibiae browned or blackened centrally, all tarsi apically browned, the fore pair more extensively than the others. Apical ventral spur on mid tibia black, of moderate length. Wings brownish hyaline, veins brown and rather thick. Third costal division from two-thirds to three-fourths as long as second; third vein distinctly curved forward, ending distinctly farther in front of apex of wing than the fourth does behind it, the latter not noticeably bent or arched beyond the outer cross-vein, and almost straight so that the first posterior cell is distinctly widened apically; penultimate section of third vein shorter than that of fourth, the latter about half as long as ultimate section of fifth and one-sixth as long as its own ultimate section, the apical section of fifth vein about two-thirds as long as its preceding section. Abdomen yellow, broadly brown to black on dorsum, the hairs black. Male hypopygium with black basal segment, the superior forceps brown, the inferior processes yellowish-brown. Posterior and lateral aspects of hypopygium as Figure 11. Genital lamellae of female black, short and stout, broadly rounded at apices. Length, 2–2·5 mm.

Type, ♂, allotype, and 3 paratypes, Blundell's, A.C.T. (L. F. Graham, H. M. Barnes); one paratype, Mt. Lofty Rge., S. Aust. (A. H. Elston).

The slender superior hypopygial forceps of the male are characteristic of the species.

Oscinis canaliculata Becker, var. trisulcata, n. var.

Becker has described the typical form of this species as having the legs except the apices of the tarsi yellow. In the Australian variety the fore femora are browned on a short stretch of dorsum on apical half, while the mid and hind femora are almost imperceptibly similarly browned, and sometimes the hind tibiae are very faintly browned at middle. The Formosan form is stated to have but two striae or furrows on each side of the triangle while in *trisulcata* there are three or four such furrows, of which the inner two usually curve round and connect in front of the anterior ocellus. The third antennal segment is about 1·5 times as long as wide and quite noticeably angulate at apex above, the aristae are yellow on the basal two segments and white on the third, the latter being minutely white pubescent. It is worth noting that, if this is the species Becker had before him, he did not state in his description that the third antennal segment was unusually long for the genus he placed the species in. In fact the character would actually place the species in the genus *Parectecephala* Becker in his generic key. The latter, however, has the mesopleura haired behind, while in this species the mesopleura is bare. The mesonotal vittae are five in number, dull black because of greyish-brown dusting, and the pleural spots are usually five in number, but the one on the pteropleura is very faint and the sternopleural one is mainly or entirely red, as is also sometimes even the one on the mesopleura. In all three males before me the scutellum is broadly browned on the disc, but in the one female the scutellum is entirely yellow. The third wing-vein is very slightly curved forward at apex, and the fourth is practically straight beyond the outer cross-vein so that the first posterior cell is widened a little at apex, and the ultimate section of the fifth vein is about half as long as its preceding one. Length, 2·5 mm.

Type, ♂, Como, N.S.W. (Peterson). Allotype, and two male paratypes, Blundell's, A.C.T. (A. Tonnoir, L. F. Graham).

It is not improbable that this is a distinct species rather than a variety of the Formosan one, but they are so similar that only a direct comparison of specimens will decide the point.

Oscinis pallidiseta (Malloch).

Proc. Linn. Soc. N.S.W., lvi, 1931, 71.

This species is one of the few in the genus in Australia that have the aristae with the third segment white and minutely white pubescent. Here the basal two segments are yellow. The frontal triangle is highly polished, brownish-black in colour, and entirely smooth, filling more than three-fourths of the width at vertex, with the sides very slightly concave and the apex at anterior margin of frons. The two pairs of vertical bristles are quite prominent for this genus and the ocellar and postvertical pairs are short and very fine. Third antennal segment broader and wider than in the next preceding species, with distinct upper apical angle, black above, yellow below; palpi brownish-yellow; gena at middle about half as high as width of third antennal segment. The mesonotal vittae are broad, rather dull because of brown dusting, and the scutellum is broadly infuscated on the sides. Legs slender, largely browned.

Sydney, N.S.W. I have seen only the type specimen.

Oscinis variseta, n. sp.

Head yellow, paler below and on face, the triangle glossy brownish-black, with no trace of sulci or submarginal hairs, filling a little more than half of the vertex, the sides almost straight, the apex at anterior margin of frons. In both the

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specimens at hand the frons is sunken on each side of the triangle though this may be abnormal, but the surface is distinctly shiny, which is not the case in related species, and the higher power lenses show minute longitudinal striae, most noticeable behind. The antennae are smaller than in the immediately preceding species, with the third segment not longer than its greatest width, slightly angulate at apex above, yellow below, black above, the two other segments black; aristae black or fuscous on basal two segments, white on the third slender segment. Gena rather swollen centrally, wider than the third antennal segment. Palpi yellow.

Thorax yellow, glossy, the mesonotum with three broad glossy-black vittae. the central one extending from over anterior curve to midway from suture to posterior margin, the other two extending from posterior edges of humeral callosities to a short distance from postalar callosities, widened in front of suture and again behind it owing to the fusion with the postsutural short sublateral vitta. Surface hairs fine and black, not situated in noticeable punctures; notopleurals 1 + 2; humeri with a black spot. Pleura with four black spots, the prothoracic spiracular one lacking. Scutellum with a dark mark at basal angles, hairs fine and dark, the margin with about four black setulae, the apical pair strongest, disc convex. Legs yellow, all femora extensively infuscated centrally, the tibiae, except the hind pair, narrowly infuscated centrally, fore tarsi almost entirely, and the apices of other tarsi browned. Wings greyish hyaline, veins brown. Third vein straight on apical section, fourth almost straight beyond the outer cross-vein, diverging from third apically; second costal section hardly longer than third; penultimate section of third vein about half as long as that of fourth vein, the latter about one-fourth as long as its ultimate section and longer than ultimate section of fifth vein, the latter not much if any more than one-third as long as its preceding section. Abdomen yellow, the tergites broadly infuscated, the bases and apices narrowly pale; genital lamellae of female black, slender and of moderate length. Length, 2·5 mm.

Type ♀ and one paratype, Mt. Wellington, Tasmania, 15 Nov., 1922 (A. Tonnoir).

A very distinct species because of the shiny and microscopically striate lateral parts of frons and the trivittate mesonotum. The short ultimate section of the fifth vein is also a rare character in the genus.

Oscinis ocellaris, n. sp.

♂, ♀.—Head testaceous yellow, frons darker, the triangle yellow to brown, rather variable, the ocellar spot black, and a black or dark brown stripe running from ocelli to anterior extremity, the centre rather depressed, which appearance is more emphasized by the dark central stripe, the surface without hairs, the sides almost straight, the tip at about one-fourth from anterior margin of frons. Ocellar bristles much longer and stronger than usual, about as long and strong as either pair of verticals, the postvertical pair very short; surface hairs black, not numerous, those along the edges of frons and triangle stronger than the others. Occiput with a central brownish-black mark that is as wide as the triangle at vertex. Antennae yellow, third segment infuscated above and at apex; aristae fuscous, rather distinctly pubescent. Eyes subnude, oblique, greatest height and greatest length subequal. Gena a little less than equal to width of third antennal segment. Prelabrum and palpi yellow.

Thorax yellow, shiny, not glossy, mesonotum with five rather dull black vittae, the short postsutural one very narrowly separated from the submedian one, the disc rather dark brownish-yellow, the whole surface with fine brownish-dusting. Surface hairs short, decumbent, black, and not inserted in distinct punctures, the

bristling normal. Pleura paler than mesonotum, with 5 dark spots, the three upper paler, the one on the sternopleura and that on hypopleura black. Scutellum yellow, largely blackened on sides, sometimes only a central line and apex yellow, hairs and bristles black. Apical pair of bristles longer and stronger than usual, distinctly longer than the dorsocentral bristles, the lateral pair well in front of the apicals and about as long as the dorsocentrals. Legs brownish-yellow, without black markings, the femora and apices of tarsi a little darker than other parts; mid tibia with a moderate apical ventral black spur. Wings brownish hyaline, veins brown, rather thick. Third section of costa more than half as long as second; third vein sloping forward and ending in costa distinctly farther before apex of wing than fourth vein does behind it, the first posterior cell widened apically; penultimate section of third vein about half as long as penultimate section of fourth; ultimate section of fifth vein about half as long as its penultimate section. Halteres yellow, knobs white. Abdomen dark brown, shiny, basal segment and apex of fifth yellow. Length, 2 mm.

Type, ♂, Sydney, N.S.W., 23.xi.1924. Allotype, Mooni, nr. Cott's, 14.ii.1925. Paratype, Eidsvold, Qsld. The first two specimens belong to the Public Health Dept. collection, Sydney.

Oscinis subarcuata, n. sp.

♂.—Face and genae pale testaceous-yellow, densely white-dusted, the frons darker brownish-yellow, paler in front, triangle entirely glossy-black, occiput except the margin and lower half black; antennae black, second segment brownish-red at base, aristae black; hairs and bristles on frons black, genal hairs yellow. Frons at vertex about half the head-width, the triangle extending to anterior margin, rather narrow, with almost straight sides, the width at vertex hardly three-fifths that of vertex, the surface almost smooth, only a few irregular faint impressed lines on the lateral portions, but no distinct sulci or furrows; ocellar bristles erect and slightly divergent in type, the four verticals and the postverticals quite fine and not long; frontal hairs stiff, those along the sides of the triangle forming a series that is more evident than that along eye-margins. Face vertical, the vibrissal angle more developed than usual in this genus but not protruded, foveae undeveloped; eye slightly oblique, a little higher than long, bare; gena about one-fifth of the eye height, and about four-fifths as high as width of the third antennal segment, the latter wider than long, broadly rounded at apex; aristae subnude, second segment four times as long as thick; prelabrum black, glossy; proboscis yellowish-brown, thick, with stout fleshy reflexed apical section; palpi lanceolate, yellow at bases, black at apices.

Thorax glossy brownish-yellow, with the usual five glossy-black vittae, the three central widened in front, the median one entire, the submedian pair not attaining either extremity of mesonotum, the sublaterals short and postsutural, scutellum broadly infuscated at base, pleura with four large black marks, and a small one below the prothoracic spiracle; hairs and bristles black. Dorsal hairs quite dense, short and decumbent, not inserted in distinct punctures, humeral present, notopleurals 1 + 2; scutellum convex, narrowly rounded at apex, with four fine black marginal bristles. Legs brownish-yellow, fore coxae browned in front, all femora extensively blackened, hind tibiae black except at extremities, mid tibiae brown centrally, fore tarsi and apices of other tarsi brown; mid tibial spur black and of moderate length. Wings brownish hyaline, veins brown. First costal section almost as long as second, the latter from fusion of first vein and costa nearly twice as long as the third section, the costal vein quite noticeably thickened

from fusion of veins and tapered off apically; inner cross-vein about one-third from apex of discal cell, penultimate sections of third and fourth veins subequal in length, the latter but slightly shorter than ultimate section of fifth, veins 3 and 4 divergent apically, ultimate section of fifth vein a little more than one-third as long as its penultimate section. Abdomen glossy blackish-brown on dorsum, only narrowly yellow on sides as seen from above and at apex; hairs black. Knobs of halteres cream-coloured. Length, 3 mm.

Type, Eaglehawk Neck, Tasmania, 20.xi.1922 (A. L. Tonnoir).

Oscinis botanica, n. sp.

♂.—A much smaller and even darker coloured species than *subarcuata*, with more or less indicated mesonotal dusting, and with the frontal triangle different.

Face and genae testaceous yellow, densely greyish-white-dusted, frons dull yellow, the triangle glossy-black, occiput black, narrowly brown on edges; hairs and bristles black. Antennae entirely black; aristae black. Proboscis brown; palpi black. Frons at vertex half the head-width, narrowed in front, triangle occupying three-fourths of the width of vertex, and extending to anterior margin, the sides quite evidently emarginate on anterior third, the surface smooth; ocellar bristles larger than the postvertical pair, proclinate and divergent, the four verticals longer and stronger than the postverticals; surface hairs stiff, not very long. Face shallowly concave in profile, vibrissal angle slightly produced, foveae hardly evident. Gena about one-fifth as high as eye and about four-fifths as high as width of third antennal segment, the latter about as high as wide and more narrowly rounded at apex than in *subarcuata*; eye a little higher than long, slightly oblique, bare.

Thorax marked as in *subarcuata*, but the vittae not as clearly differentiated. Scutellum black, rather dull, convex, narrowly rounded at apex. Legs black, apices of fore coxae, the knees narrowly, and bases of tarsi brownish-yellow. Apical ventral spur of mid tibia black, straight. Wings greyish hyaline, veins blackish-brown. First costal section about two-thirds as long as second, the latter not twice as long as third; the third vein very distinctly curved forward and ending in margin farther before tip of wing than fourth does behind it; ultimate section of fifth vein about three-fourths as long as its penultimate section; costal vein not noticeably thickened beyond first vein. Abdomen black, quite dull, yellowish at apex of fifth tergite. Knobs of halteres pale yellow. Length, 1·75 mm.

Type, Botany Bay, N.S.W., on flowers (H. Peterson).

Oscinis politella, n. sp.

♀.—Head pale testaceous yellow, occiput black on upper half, the lateral margins hardly paler, yellow below, frons yellow, brownish above and along triangle, the triangle glossy brownish-black, paler in front; antennae with the third segment infuscated on upper and apical portions, aristae black on basal thickened part and brownish-yellow on apical part; proboscis and palpi yellow; prelabrum black in front; hairs and bristles on frons black, hairs on genae yellow. Frons at vertex more than half the head-width; triangle at vertex three-fifths of width between eyes, extending as a slender point to anterior margin, the sides slightly emarginate, surface smooth, without hairs even on sides; ocellar bristles fine, divergent and proclinate, longer than the short postvertical pair, the four verticals fine and longer than the ocellars; surface hairs on frons fine and rather numerous, those along the margins of the triangle longer than the others, except a few on upper part of each orbit. Face concave slightly in profile, the parafacials

about half as wide as height of gena, the latter three-fourths as high as width of third antennal segment; eye a little higher than long and slightly oblique, bare, five times as high as gena. Third antennal segment about as long as wide, with a slight angle at upper apex; arista with the second segment about four times as long as thick, third subnude.

Thorax glossy-yellow, the mesonotum slightly browned and with five glossy-black vittae, the central one entire, the submedian pair abbreviated in front and behind, the sublaterals postsutural; humeri with a large black spot; surface hairs and the bristles black, the latter as follows: 1 humeral, notopleurals 1 + 2, postalars 2, and 1 pair of dorsocentrals; the hairs not inserted in punctures. Scutellum pale yellow, with a small black mark on each side at base that is hardly visible from above, disc but little convex, outline subtriangular, slightly produced between the apical pair of bristles which are about as long as scutellum and much longer than the preapical pair, surface hairs fine and black. Pleura with three black marks, a large one on lower part of sternopleura, a small one on lower margin of mesopleura, and a round one on hypopleura, and traces of dark spots on upper central part of mesopleura and centre of pteropleura; sternopleural hairs yellow. Legs yellow, apical two or three segments of fore tarsi and apical one of other tarsi browned; apical ventral spur on mid tibia black, about as long as apical diameter of tibia; fore tarsi not dilated. Wings brownish hyaline, veins brown. First costal division about two-thirds as long as second, the latter not 1·5 times as long as third; second vein straight, not noticeably bent forward at apex, third diverging from second and not curved forward at apex, ending in costa a little farther before wing tip than does the fourth behind it, first posterior cell widened to apex; inner cross-vein almost below apex of first vein and at two-fifths from apex of discal cell; penultimate section of third vein but slightly shorter than penultimate section of fourth, the latter three-fourths as long as ultimate section of fifth, which latter is almost exactly half as long as discal cell. Abdomen dark brown, glossy, with traces of yellow at apices of tergites, most distinct on fifth tergite; hairs dark. Halteres white. Length, 2·5 mm.

Type, Forrest, A.C.T., 23.ii.1930 (A. L. Tonnoir).

It appears highly probable that the pleural spots will be more numerous in other specimens of this species.

Oscinis varivitta, n. sp.

♀.—The type specimen is slightly teneral and the shrunken head gives little ground for accuracy in dimensional description, but the following is as definite as is possible under the circumstances. Head yellow, only the small ocellar spot and a large central quadrate mark on the occiput black, the triangle glossy and with a trace of a brown central vitta from ocelli to anterior extremity; antennae with upper apical part of third segment brown; aristae dark brown; surface hairs and bristles on frons black, genal hairs yellow. Frons longer than its central width, narrowed in front, the triangle apparently filling the entire vertex because the latter is glossy at upper lateral angles of frons, longer than its upper width, extending to anterior margin rather widely, the surface smooth, but with one or two series of fine black hairs on each side from level of anterior ocellus to near anterior extremity. It appears worth noting here that in the group of species that have a broad central sulcus on the triangle all but one, *blundelli*, have hairs on the sides of the triangle, and that in the present species it may be that the sulcus is not developed because of the shrinkage of the head, which has pressed in on the triangle from the sides. Ocellar bristles fine, proclinate and divergent,

longer than the short, fine postvertical pair, the verticals longer and stronger than the ocellars. Eye higher than long, slightly oblique, bare; parafacial visible in profile; gena higher than width of third antennal segment, the latter about as long as wide, and rounded at apex; arista with the second segment about twice as long as thick, third slender, subnude. Proboscis short and stout, yellow, palpi unicolorous; prelabrum honey-yellow, possibly darker in well-matured examples.

Thorax glossy honey-yellow, the mesonotum with five black vittae of which the central one is extensively reddish-yellow centrally, black only at the extremities, and the submedian pair reddish-yellow at suture, the sublaterals short and postsutural; humeri slightly reddish-yellow above; all hairs and bristles black. Pleura with reddish marks on lower margin of mesopleura, lower half or more of the sternopleura, and on hypopleura. Scutellum yellow; postnotum black. Bristles on mesonotum as follows: Humeral 1, notopleurals 1 + 2, postalars 2, and dorsocentrals 1 pair; surface hairs moderately numerous, short and decumbent. Scutellum slightly convex on disc, narrowly rounded at apex, the apical pair of bristles as long as scutellum and much longer than the preapical pair, discal hairs short and fine. Legs yellow, rather stout, the apical ventral spur on mid tibia black, short. Wings greyish hyaline, more pointed than in the immediately preceding species, and with almost identical venation. Abdomen yellow, each tergite from second to fifth with a transverse blackish-brown fascia near base, usually widened centrally and at lateral curves; surface hairs black, genital lamellae blackish-brown, slender and finely haired. Halteres lemon-yellow. Length, 3·5 mm.

Type, Eaglehawk Neck, Tasm., 17.xi.1922 (A. L. Tonnoir).

The invasion of the frontal triangle by the hairs is characteristic of such genera as *Ectecephala* Macquart, but here I have not considered it as the basis for even the subgeneric segregation of the species of *Oscinis* in which the character occurs, though it is probable that some subsequent worker on the family may do so.

Oscinis suffusa, n. sp.

Head testaceous yellow, frons orange-yellow, darker above, the triangle glossy-black, slightly less intense posteriorly on angles, occiput black centrally, merging into brown laterally and almost yellow on extreme edges, yellow below; antennae yellow, third segment black except on lower basal portion; aristae black; proboscis and palpi orange-yellow; prelabrum black; hairs and bristles of frons black, genal hairs yellow. Frons in profile projecting beyond eyes by about the width of third antennal segment, face receding below, parafacial at centre linear; frons at vertex half the head-width, its length about 1·25 times its width, slightly narrowed in front; triangle extending as a line to anterior margin, widened from anterior fourth to vertex, the sides practically straight, the surface smooth, but there is a short central depression, though not a sulcus, in front of the anterior ocellus for about a third of the distance to apex of the side part; no lateral hairs present; ocellar bristles almost erect, and divergent, subequal in length to the postvertical pair, the four verticals a little longer and stronger; surface hairs fine, becoming more dense in front. Third antennal segment a little wider than long, broadly rounded in front; arista with the second segment about three times as long as thick, third minutely pubescent. Eye about as high as long, narrowed in front, bare. Gena two-thirds as high as width of third antennal segment.

Thorax with the mesonotum almost entirely black, the usual vittae separated by hardly visible brownish-yellow lines, only the humeral and notopleural regions noticeably yellow, the humeri with a black spot; pleura pale yellow, with large black spots on sternopleura, lower half of the mesopleura, the hypopleura and

pteropleura; mesonotum rather dull because of the slight brownish dust present and the small rather closely placed piliferous punctures; surface hairs and bristles black. Bristles as in the immediately preceding species. Scutellum yellow, rounded in outline, convex on disc, with numerous fine black discal hairs and about 6 black marginal bristles, the apical pair the longest, subequal in length to the scutellum. Legs yellow, bases of fore coxae, posterior surface of fore femora, centre of mid femora, parts of hind femora, and the centre of hind tibiae, blackened or browned; mid tibia with the apical ventral spur short and black. Wings greyish hyaline, veins brown, venation almost as in the two next preceding species. Abdomen glossy blackish-brown, yellow at base, and on the apex of fifth tergite, hairs black, genital lamellae blackish-brown, slender, and finely haired. Knobs of halteres dull yellow, darkened above. Length, 3·5 mm.

Type, Canberra, A.C.T., 1.x.1930 (A. L. Tonnoir).

OSCINIS ALBOHALTERATA, n. sp.

♂, ♀.—Head pale yellow, the face and genae always paler than the frons, the latter with a glossy-black triangle, the posterior lateral angles of which are yellow; antennae with the third segment almost all black, usually more or less distinctly yellow on lower basal part; aristae black on basal two segments, third yellowish-brown; proboscis and palpi yellow; prelabrum black; occiput black on upper half, the lateral margins and lower half yellow; hairs and bristles of frons black; genal hairs yellow. Frons less than half the head-width, parallel-sided, subquadrate, surface hairs longer and denser in front, lacking between upper triangle and orbits; triangle extending as a line to anterior margin, the linear part yellow and about one-fourth as long as the wide part, the latter smooth and without hairs. Ocellar bristles divergent and proclinate, about as long as postverticals and shorter than the verticals. Third antennal segment about as long as wide, broadly rounded at apex; arista tapered at base, subnude. Eye a little higher than long, slightly oblique, bare. Gena two-thirds as high as width of third antennal segment and one-fifth as high as eye. Parafacials in profile invisible. Proboscis stout.

Thorax glossy-yellow, mesonotum with five black vittae that are almost glossy, though overlaid with indistinct brownish dust, the central vitta entire though the posterior extremity is merely brown and not deep black, the submedian pair incomplete in front and behind, dilated before suture, the sublaterals short and postsutural; all hairs and bristles black; humeri with a black spot, and a small black dot in front of suture laterad of the submedian vittae. Pleurae with 4 black marks, none below the prothoracic spiracle, the mesopleural one sometimes bisected posteriorly. Scutellum short, convex on disc, narrowly rounded in outline, entirely yellow, with numerous black discal hairs and four marginal bristles. Mesonotal bristles normal in number. Legs yellow, fore femur with a brown patch on postero-dorsal surface near apex, the other femora sometimes slightly browned centrally, hind tibia brown centrally, fore tarsi browned apically, the other pairs with apical two segments browned. Wings greyish hyaline, veins fuscous. Venation almost as in the preceding species but the penultimate section of third vein shorter than that of fourth. Abdomen yellow, slightly shiny, the dorsum largely brown with the bases of the tergites darker. Male hypopygium with small beak-like forceps. Halteres yellow. Length, 2 mm.

Type, ♂, allotype, and 10 paratypes, Sydney, N.S.W. Paratypes, Blundell's, A.C.T., and Mt. Kosciusko, N.S.W. (A. L. Tonnoir).

Melanum Becker.

Arch. Zool. Budapest, i, 1910, 50.

This genus is readily distinguished from other Chloropinae by the angular and slightly produced vibrissal angle, and the rather elongated and geniculated proboscis. The third antennal segment is not noticeably longer than wide and is rounded at apex, and black in both the species before me; the palpi are also black. In other respects very similar to *Oscinis*.

The two species from Australia may be separated as in the following key:

1. Frontal triangle shiny black, rather broadly triangular, not extending to anterior margin of frons, with about a dozen fine longitudinal striae .. *multisulcatum*, n. sp.
   Frontal triangle glossy-black, not striate, with or without a shallow central longitudinal sulcus ..... *montanum*, n. sp.

Melanum multisulcatum, n. sp. Figs. 12, 13.

♀.—Face, genae, and lower half of postocular orbits testaceous yellow, frons darker yellow, merging into dark brown on upper half, occiput black, triangle shiny black; antennae and palpi black, aristae fuscous; all hairs and bristles black. Frons almost half the width of head at vertex, narrowed in front, triangle about three-fourths the width of vertex, broadly triangular, its apex falling short of attaining anterior margin, the sides slightly emarginate, surface with about a dozen fine striae. All four vertical bristles distinct though not very conspicuous, the ocellar and postvertical pairs much shorter and finer, subequal, postverticals not markedly incurved, the ocellars proclinate and slightly if at all divergent; frontal hairs longest along eyes and triangle. Profile as Figure 12. Arista subnude. Palpi rather large and lanceolate. Upper occiput brown-dusted on sides.

Thorax with the dorsum brownish-black, not shiny, greyish-dusted, most distinctly so on lateral margins, without well-defined vittae; scutellum of same colour, paler, yellowish-brown, centrally. Humeral and anterior notopleural bristles much shorter and weaker than the posterior notopleurals, the surface hairs black, short, fine, and decumbent. Scutellum with two moderately long apical and two much shorter preapical marginal bristles, the discal hairs longer than those on mesonotum. Pleurae brownish-yellow, glossy except on upper posterior portion of the mesopleura, the upper half of the pteropleura and on hypopleura, which are grey-dusted, a fuscous spot on prothoracic spiracular region, a glossy-black mark on lower margin of mesopleura, one on pteropleura, and the lower half or more of the sternopleura glossy-black, the hypopleura with another black mark; postnotum black centrally. Legs dull black, extreme apices of femora, the bases of tibiae more broadly, fulvous yellow, the base of metatarsi brownish-yellow. No exceptional armature on legs, the mid tibiae with a black apical ventral spur of moderate length. Wings brownish hyaline, veins brown. Venation as Figure 13. Abdomen dull dark brown, with fine black hairs that are longest at apices of the tergites. Stems of halteres brown, knobs pale yellow. Length, 2 mm.

Type, Barrington Tops, N.S.W., 25.i.1922 (Nicholson).

Melanum montanum, n. sp.

♀.—Similar to the preceding species in general colour, but the two specimens appear to have been in liquid so that fine distinctions in colour can not be dependably drawn. However, the frons is entirely brownish-black, the triangle is entirely glossy-black, the palpi are yellowish at bases, and the second antennal segment is brownish-yellow, distinctly paler than the black third segment. The lack of minute longitudinal striae on the triangle appears to me the most dependable distinguishing character, but it is impossible to determine whether

there may be a longitudinal sulcus from the ocelli to anterior extremity in well preserved specimens, though there is such a sulcus or depression in one specimen and hardly a trace of it in the other now before me.

Thorax darker on sides than in the preceding species, the mesonotum paler between three glossy-black vittae, not noticeably dusted, though possibly abraded. In other respects as above, but the scutellum is entirely black. Wings brownish hyaline, veins brown, venation almost as in the preceding species, but the third vein not as noticeably bent forward. Abdomen black, almost glossy. Legs more extensively yellow, the tibiae blackened centrally, and the tarsi yellow on the basal three or four segments. Length, 2 mm.

Type and one paratype, Mt. Lofty Rge., S. Aust. (A. H. Elston).

Chloropisca Loew.

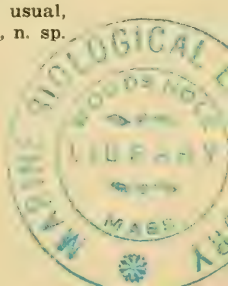
Zeitschr. f. Entom. Breslau, xv, 1866, 79; Becker, *Ann. Mus. Nat. Hung.*, ix, 1911, 73; Malloch, Proc. Linn. Soc. N.S.W., lii, 1927, 429.

This genus was originally distinguished from *Chlorops* Meigen by its describer on the basis of the flattened disc of the scutellum with its more or less definite marginal rim above and approximated pair of apical bristles. These characters do not hold good throughout the genus, and some years ago I introduced as a distinguishing character one that is invariably present in the genus. This consists of a flattened elongate-oval area on the posterodorsal surface of the hind tibia near the middle that is furnished with microscopic pile, usually changeable in colour when viewed from different angles. I incline to the restriction of the genus to those species in which the mesopleura is microscopically haired on the posterior half or less.

There are two species already on the Australian list, one of them, *subnotata* Malloch, being a characteristic species with distinctly flattened disc of the scutellum and closely approximated apical bristles, as well as hairs on the hind portion of the mesopleura, but of the other, *monticola* Malloch, I have seen but one specimen, and it has been pinned in such a manner that it is impossible to tell if the mesopleural hairs are present or not. I have now a third species, unfortunately similarly pinned, that I place tentatively in this genus. The only other genus that it may possibly belong to is *Chloropsina* Becker, of which I do not know the genotype, but the only species I have placed therein from Australia has not a sensory area on the hind tibia, and has the halteres with black knobs.

The three species now before me may be distinguished as below.

1. Scutellum fully as long as wide, somewhat subtriangular, tapered apically, flattened on disc, with a distinct sharp marginal rim; frontal triangle not entirely black, partly yellow, more or less irregularly infuscated, and with fine hairs invading its sides; mesonotum yellow, with five glossy black vittae .... *subnotata* Malloch
   Scutellum wider than long, not or but little flattened on disc, not rimmed; frontal triangle entirely glossy-black, and with no hairs invading its sides; mesonotum glossy-black 2
2. Palpi yellow; antennae orange-yellow, third segment infuscated except at base; frontal triangle narrowed to a point in front, the sides slightly emarginate (Fig. 14); penultimate section of third vein about two-thirds as long as penultimate section of fourth; discal cell below inner cross-vein a little wider than length of the latter ..... *monticola* Malloch
   Palpi black; antennae entirely black; frontal triangle not as much narrowed in front, the sides slightly convex (Fig. 15); penultimate section of third vein not half as long as penultimate section of fourth vein; discal cell narrower than usual, below inner cross-vein not as wide as length of latter ..... *sydneyensis*, n. sp.



CHLOROPISCA SUBNOTATA Malloch.

PROC. LINN. SOC. N.S.W., lii, 1927, 429.

I have seen five specimens of this species, all from New South Wales in the vicinity of Sydney.

CHLOROPISCA MONTICOLA Malloch. Fig. 14.

PROC. LINN. SOC. N.S.W., lii, 1927, 430.

I have before me only the type specimen, a female, of this species, from Blue Mts., N.S.W.

Both the above belong to the Health Department collection in Sydney.

CHLOROPISCA SYDNEYENSIS, n. sp. Fig. 15.

♀.—A small species very like *monticola*, differing in being darker in general colour, with the pleural markings larger, the antennae and palpi black, aristae black, legs honey-yellow, apices of fore tarsi brown. Frons yellow, dull, at vertex about two-fifths of the head-width, narrowed to anterior margin, the triangle glossy-black, as Figure 15. Eye almost nude. Antennae entirely black, third segment not as long as high, broadly rounded at apex; aristae entirely black, short pubescent, thickened at base. Gena not more than half as high as width of third antennal segment and about one-eighth as high as eye, with some very fine pale hairs along lower edge. Proboscis short and stout, dark brown; palpi black. Thoracic dorsum and pleura glossy-black, the former with slight brownish dust, the notopleural areas each with a brownish-yellow mark and the pleural sutures also brownish-yellow. Surface hairs very short, dark, and decumbent; notopleurals 1+2. Scutellum yellow, broader than long, rounded at apex and convex on disc, with some very fine short discal hairs and four fine black bristles, the apical pair the longer, and not very closely placed. Legs honey-yellow, apical tarsal segment brown. Wing greyish hyaline, veins brown. First and third costal sections subequal in length, second about 1·25 as long as either; veins 3 and 4 divergent apically; ultimate section of fifth vein not more than one-third as long as its penultimate section. Abdomen glossy-black, venter yellow, hairs black, genital lamellae slender and finely haired. Halteres pale yellow. Length, 1·5 mm.

Type, Sydney, N.S.W., 2.ix.1919 (Health Dept.).

PEMPHIGONOTUS Lamb.

Ann. Mag. Nat. Hist., xix, ser. 8, 1917, 54.

This genus contains three species at present, one of which, the genotype, occurs in northern Australia. The mesopleura is largely haired and the hind tibia has an elongate sensory area as in *Chloropisca*; the lack of a defined frontal triangle is distinctive. There are several structural characters, such as the bristly-haired mid tibia and the flattened disc of the mesonotum, distinguishing the male from the female in the Australian species that do not occur in the other species.

PEMPHIGONOTUS MIRABILIS Lamb.

Ann. Mag. Nat. Hist., xix, ser. 8, 1917, 55.

A large, robust, brownish-yellow species, with unicolorous legs, and the wings brown, paler on hind margin, darkest in the male. Length, 5–6·5 mm.

Type locality, Melville Is. I have before me one paratype and some specimens from Darwin, N.T. (Handschin).

FORMOSINA Becker.

Ann. Mus. Nat. Hung., ix, 1911, 78.

The highly convex thoracic dorsum, large frontal triangle, that extends to the anterior margin, and the location of the scutellar bristles on the lower edge of the scutellum distinguish this genus from *Chloropisca* and *Pseudoformosina*.

FORMOSINA AUSTRALIS Becker.

Ann. Mus. Nat. Hung., ix, 1911, 80.

Mesonotum entirely smooth, unpunctured, bare, pleura and mesonotum entirely shiny black, without yellow spot, frons black, scutellum black with yellow tip, abdomen and legs black, metatarsi whitish-yellow. A robust species. Halteres yellow. Frons narrower than one eye, with narrow shiny-black triangle that has on apical half a shallow sulcus and a furrow on either side. Antennae red, with fine bare arista.

Cooktown, Queensland.

This species is unknown to me and the above abridged description is taken from Becker's work on the family in the Indo-Australian Region.

There are about a dozen species of this genus known, all, with the exception of *australis*, being from the Malayan and Oriental regions with some extending the range into southern India. It is more than probable that other species will be met with in northern Australia.

I take this opportunity to erect a new genus, *Pseudoformosina*, for the reception of a species that has heretofore been erroneously placed generically.

PSEUDOFORMOSINA, n. gen.

I am erecting this genus for the reception of *Chlorops nicobarensis* Schiner.[3] It has a distinct sensory area on the hind tibia as in *Formosina*, and the genotype has a large pale yellow mark on each notopleural region as in most species of that genus, though this feature is lacking in *F. australis* Becker. It differs from *Formosina* in having the frontal triangle not more than two-thirds as long as frons, instead of attaining the anterior margin, the genae higher than width of third antennal segment and about one-third as high as eye, not almost linear, and in being more normal in form, more like typical species of *Oscinis*, with the mesonotum moderately convex and not prominently so. The pair of apical bristles on the scutellum are situated close to the upper edge, and not as in *Formosina* on the lower edge.

PSEUDOFORMOSINA NICOBARENSIS (Schiner).

A black, slightly shiny species, with head yellow, occiput black, frontal triangle glossy, generally more or less browned and smooth, the frons less shiny and with sparse pale forwardly-directed hairs. Third antennal segment about 1·5 times as long as wide, pale brown, broadly rounded at apex, aristae brown at base, yellow beyond, subnude, about 1·5 times as long as third antennal segment. Eyes almost round, bare. Ocellars proclinate and divergent, verticals fine; all bristles pale.

Thorax with slight grey-dusting, most distinct on the yellow lateral marks and on posterior part of mesopleura. Scutellum yellow, with a black mark below each basal angle, the hairs and bristles yellow, the apical bristles very closely placed. Legs black, rather stout, mid tibia without erect posterior hairs, all knees, mid tibiae, and tarsi, brownish-yellow, hind tarsi brown. Wings brownish hyaline, suffused with brown from base to apex as far back as anterior third of first

[3] Schiner, Novara Reise, ii, ib, 1868, 244. [Becker's citation is "Novara Reise. 244.37.(1868)", in *Ann. Mus. Nat. Hung.*, ix, 1911, 35. This has been frequently quoted by later authors. As cited by Becker it refers to page 244, species no. 37.—Ed.]

posterior cell apically, and over fifth vein to apex of discal cell. Abdomen shiny brownish-black, apex of fifth tergite yellow, hairs fine, yellow. Halteres cream-coloured. Length, 3 mm.

This species ranges from the Malayan Region to New Guinea and probably occurs in northern Australia. The above description was made from Philippine specimens.

NOTES ON THE TERRESTRIAL ECOLOGY OF THE FIVE ISLANDS. I.

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(Plates xv–xix; eight Text-figures.)

[Read 26th October, 1938.]

Introduction.

The absence of any synecological study of the plant and animal complex (biome) of a terrestrial community in Australia has made impossible the practical illustration in this country of certain well-known ideas, which form the basic principles of animal ecology. In particular, this lack has handicapped the teaching of animal ecology, and has prevented the subject receiving the attention which it merits. With this in mind, the present survey was undertaken rather with a view to illustrate general principles with local examples than to develop any special theory.

The Five Islands, near Port Kembla, N.S.W., were chosen as the location for this survey, because certain factors peculiar to islands appeared to be intrinsically interesting, and also because it was hoped that the terrestrial life of these islands represented a more or less self-contained unit. Belief that we were dealing with a microcosm was soon shattered, and in this paper are set out the numerous ways in which the chosen area fails to represent a 'closed' community. It is certain, however, that these interactions with extraneous communities are far less numerous than would be the case if a mainland area had been selected.

In this paper are discussed the geological and physiographical history of the islands; the climate; the plant ecology; and the various ways in which the islands fail to represent 'closed' communities. The departure from the ideal closed community is due to products of littoral and pelagic communities, and of terrestrial communities from the mainland, becoming involved in the food-chains of the terrestrial life of the islands. Habitats for terrestrial animals, other than those embraced by communities of vascular plants, are also listed. Subsequent papers will comprise lists of all animals collected, with notes on habitat, numbers, food and enemies; from these lists it is hoped that food-chains may be deduced. Later it may be possible to compare these islands with other coastal islands.

General Description of the Five Islands.

Figure 1 shows the general disposition and size of the islands, which we have designated I–V, referring to each island subsequently by the number alone. Certain features are named on Figure 2, the names being bestowed by us for convenience. I, known locally as Big Island or Rabbit Island, is 30 acres in extent, and reaches

a height of 71 feet;[1] it is separated from the mainland at Red Point by only 500 yards, with a reef in intermediate position. Communities of vascular plants[2] occupy 57% of I. II lies to the east of I, and is connected thereto by a low isthmus, wave-swept at high tide during rough weather. II is 18 acres in extent, 49 feet at the highest point, with 45% covered by vascular plant communities. On some maps it is marked as Perkins Island. III, which lies less than 150 yards south-east of II, is 6 acres in extent, 53 feet at the highest point, with only 14% of its area occupied by communities of vascular plants, which are confined to the higher parts of its western half. IV, about 2 miles north of I, and $1\frac{3}{4}$ miles from the nearest point of the mainland, is 7 acres in extent, 43 feet at the highest point, with 15% of its area occupied by vascular plant communities. It is the island most sheltered

Fig. 1.—Map of the Five Islands (I-V) and surrounding parts, with contours (25-ft., 50-ft., thence at 50-ft. intervals), and ocean soundings (fathoms, low tide). A-B-C-D-E, F-G, line of section for Fig. 6. D represents Midway Reef. —·—·—·—·—, Approximate position of 5-fathom isobath. — — — — — — —, Approximate position of 10-fathom isobath.

[1] Heights are reckoned from mean tide level, areas as those exposed at mean tide level.

[2] All vascular plant communities, including the sparse *Scirpus nodosus* community, with low percentage cover, are included in this figure.

from southerly storms, which produce the heaviest seas to which the islands are subjected. V, the most exposed island, which lies 1 mile to the south-east of IV and 2 miles from the nearest part of the mainland, is 5½ acres in extent, 52 feet at the highest point, with about 3% covered by vascular plant communities. IV and V are referred to on most charts as the Tom Thumb Islands.

In Figure 1 are also indicated 25- and 50-feet contours, and soundings near the islands, with 5- and 10-fathom isobaths. Figures 2–4 give detailed (10-ft.) contours; those on I–IV are fairly accurate, the heights having been surveyed with pole and level and plotted in the field on vertical aerial photographs (scale 10·56 inches to the mile). The contours on V are to be regarded as form-lines, constructed, with the aid of aerial photographs, from a knowledge of the maximum height of the island (obtained trigonometrically), and its profile from several different aspects. Only a few short visits have been made to V, which is difficult of access.

Vertical aerial photographs of the islands are given in Plate xv (from 5,000 ft.), and, for I–III and the coast adjacent, in Plate xvi (from 12,000 ft.). The photographs comprising Plate xv were taken with the sun in approximately north-eastern position, while in Plate xvi the sun was approximately north-west. Shadows indicate various topographic features.

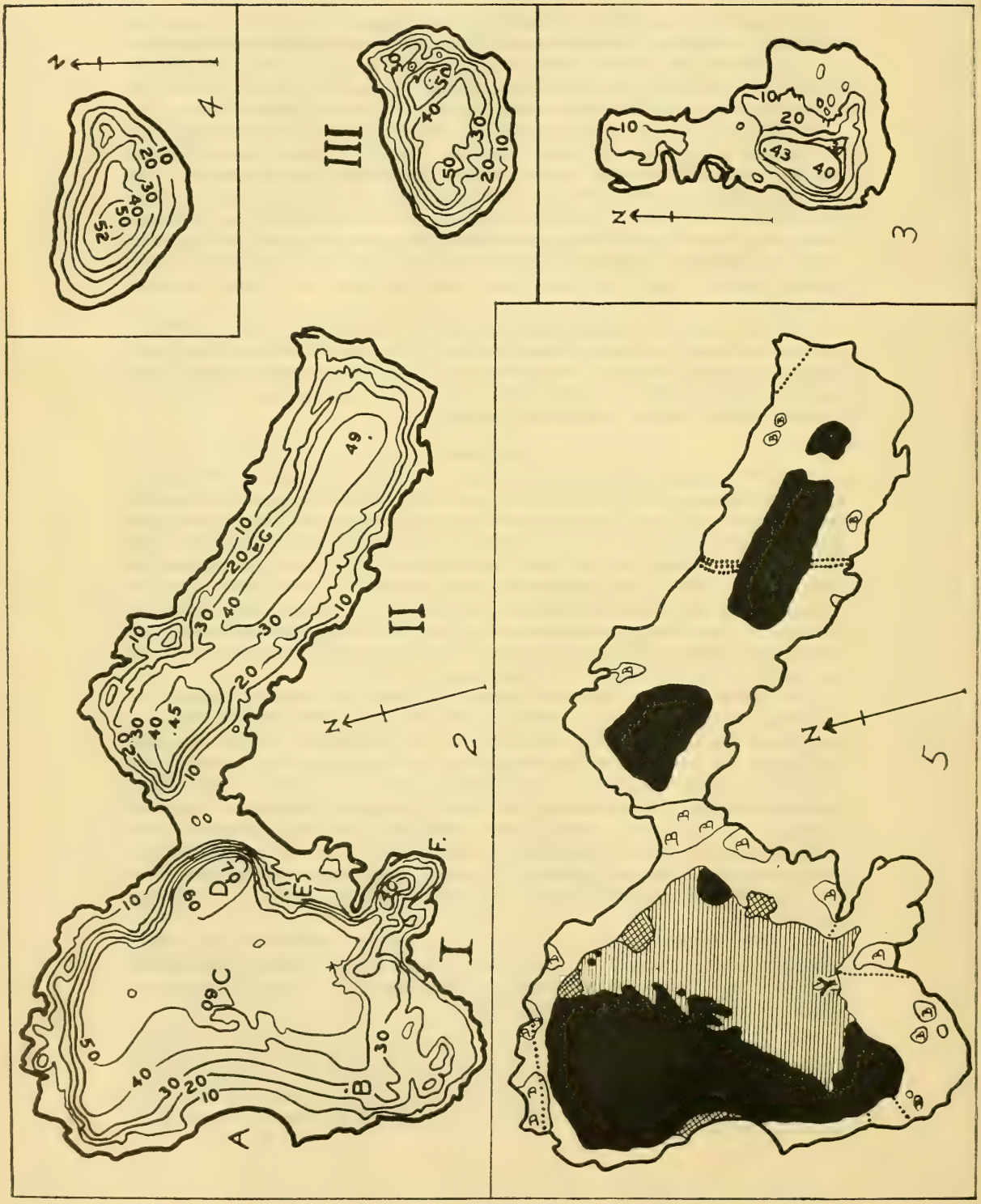
Historical.

The Five Islands were observed by Cook in 1770, and by Bass and Flinders in 1793. The former charted three islands, apparently mistaking I and II for part of the mainland; this error is easily made from the seaward side, and Cook's name, Red Point ('Some part of the Land about it appeared of that Colour') obviously derives from the colour of the rocks on the south side of I and II, although the name is now applied to the adjacent mainland, where it is quite inapt. Bass and Flinders noted four islands, apparently overlooking III. In these and other early journals we have found no descriptions of any value to the present study, e.g., information whether the dune covering of I was then present or, as now, blown off and existing as sand-drifts on the sloping sides of the islands.

The following facts have been ascertained from Port Kembla residents, as occurring within their memory: About 50 years ago, the Perkins family lived on I for several years. From this time dates the introduction of rabbits and goats[3] to I and II, and possibly also the introduction of the Buffalo Grass, *Stenotaphrum secundatum* (Walt.) Kuntze (= *S. americanum* Schr.) to I. Prior to this occupation, a Wollongong resident was in the habit of fattening young cattle, several at a time, on I and II. The rabbits, whose stock may have been augmented from without since the original introduction, are still present, though kept in check by birds of prey, and also by occasional shooting parties from Port Kembla. The goats, though established for many years, were killed off about 1917 by visiting parties.

In more recent years, I and II have been visited occasionally by camping parties, and IV very rarely. III and V are seldom, if ever, visited. The work of officers of the Prickly Pear Destruction Commission on I, II, III and IV is mentioned under the heading of Plant Ecology.

[3] In an early work, 'Our Antipodes', by Colonel Mundy (London: Richard Bentley, 1852), there is a reference to a visit to Rabbit Island (I) in 1849. It is noted that rabbits and goats had been present on this island for several years. There is no means of finding out whether descendants of these were still present when the later introductions occurred. No reference is made in this book to the state of erosion of the sand cover of the island.


4
III
3
II
2
I
5
A
B
C
D
E
F
N

Reports of Port Kembla residents indicate that no trees have been growing on any of the islands, and that the dune covering of I has been more or less in its present state during the last 50 years. It is probable that the islands never supported trees at any time.

Geology.

Islands I, II, III and V are composed of Dapto-Saddleback Dolerite, which Harper (1915) considers to be a submarine flow of Upper Permian age. The evidence for this is that the dolerite, which lies above sedimentary rocks of the Upper Marine series, is overlaid in the Albion Park district by rocks of similar age containing marine fossils. The dolerite forms an extensive flow on the mainland, the islands being almost certainly remnants of this continuous flow. The lower level of the dolerite—that is, its junction with Upper Marine sedimentary rocks—is of irregular horizon; thus, although the dip of the Upper Marine and all other strata in this district is to the north and west, the lower limit of the dolerite is concealed below sea-level on I, II, III and V, but is more than 50 feet above sea-level at Red Pt., immediately to the east of I. Midway Reef, between I and Red Pt., is composed of Upper Marine argillaceous sandstone, reaching about eight feet above mean tide level; the dolerite has here been removed by erosion, but its lower level must have been above this height. These levels are indicated on Figure 6. They may be explained by faulting, or (as in Fig. 6) by an irregular surface for the Upper Marine at the time of extrusion of the dolerite. The latter sequence is more probable, although, if we follow Harper, this irregularity could only have been due to submarine erosion. The fact that the lower level of the dolerite is below sea-level on the mainland less than a mile north of Red Pt., i.e. lower than the dip of the underlying strata would account for, supports the view that the dolerite was poured out on an irregular surface. An alternative possibility is that the dolerite is not a flow, but an irregular sill. The possibility of small faults between Midway Reef and I, and between III and V, cannot be ruled out entirely, but defies proof, as the critical points are submerged.

The distribution of the different forms of dolerite on I and II is illustrated in Figure 5. The normal rock corresponds to Type A of Browne and White (1929, Fig. 1),[4] whilst variants corresponding to Types B and D of these authors also occur on I and II. These variants seem to weather more readily than the normal type. The isthmus between I and II is composed of Type B, which possibly also occurs (submerged) between II and III. Wherever the variants occur elsewhere they are associated with ravines, inlets or large rock-pools. Tertiary basic dykes are also present on I and II, and appear to be zones of more rapid weathering.

[4] In this paper the nature of the so-called Dapto or Saddleback Dolerite is discussed; it should be termed rather a trachy-basalt.

Fig. 2.—Map of Islands **I-III**, with 10-ft. contours. Scale 10 inches to the mile. Place-names given for reference purposes: A, The Beach; B, Freshwater Springs; C, Camp Hummocks; D, High Hummock; E, Phragmites Soak; F, Periwinkle Point; G, Triangle Pool.

Fig. 3.—Map of Island **IV**, with 10-ft. contours. Scale 10 inches to the mile.

Fig. 4.—Map of Island **V**, with approximate 10-ft. contours. Note: Heights are reckoned from mean tide level in Figs. 2, 3 and 4.

Fig. 5.—Geological map of Islands **I** and **II**. Scale 10 inches to the mile. Plain white, normal type (A) of Dapto dolerite; white with 'B' and 'D', dolerite, Types B and D respectively (see text); dotted lines, dykes; black, dune sand fixed by vegetation; cross-hatched, loose sand; horizontal shading, recent sandstone; 'Y', clay soil below sandstone, exposed by weathering of latter.

Triangle Pool, a large pool just under 30 feet above mean tide level, is closely associated with the dykes diagonally crossing the eastern part of II, and the ravine on I north-east of Periwinkle Pt. is due to the weathering of a dyke in this position.

The dolerite of III and V is entirely of the normal type (A). In all parts the dolerite, in addition to the effects of differential weathering of its local forms, is of very irregular surface, being criss-crossed with large cracks, due to weathering along joint-planes (Pl. xv, xvi and xix, D, F and H). The ravines of III, and at least portion of that on the north side of II near the western end, are associated neither with any variation from the normal type of dolerite, nor with dykes.

There is little evidence on I, II, III and V of raised rock-platforms, such as are found in shales on adjacent parts of the coast. This may possibly be due to the resistant nature of the normal dolerite. In most places the dolerite slopes moderately steeply and smoothly into the sea, save for irregularities due to natural fracture, or differential weathering of the altered forms (B and D, *supra*).

Overlying the dolerite on the top of I and II is a cover of dune sand, thick on I, thin on II. This is in the form of residual hummocks, especially on I, suggesting partial removal, as detailed in the next section. The lower areas between hummocks on I are composed of a very soft recent dune-sandstone, somewhat weathered, below which a heavy clay soil is exposed in a few places. In our opinion, the original dune cover of I and II could not have formed with the sea-level in its present relation to the doleritic rocks of the islands.

IV is composed of trachy-andesite, apparently the only remnant of a local flow. The northern half of the island and the eastern parts of its southern half form a low rock-platform, mostly less than 10 feet high. The western part of the southern half of the island forms a plateau reaching more than 40 feet in height, with steep sides, except to the south-east, where the rock slopes more gently to the platform.[5] In the sides of the plateau, especially near the north-eastern corner, caves are present up to about 25 feet above mean tide level; these are probably due to differential weathering of variants from the normal rock type, rather than to wave action at a period of higher sea-level.

Physiographic Sequence.

The physiographic sequence leading to the separation of the islands may be followed from the time of the completion of the Kosciusko Uplift, probably of the order of one million years ago. At this period faulting possibly occurred between Midway Reef and I, and between III and V. From the time of the uplift, the rocks of this district have been subjected to continuous rapid erosion, resulting in the formation of a coastal plain, at present some 7 miles wide in this district (Davis, 1936*b*, and papers quoted therein). On this plain, the more resistant igneous rocks which now form the islands would, at a period of low sea-level, have been isolated elevations, comparable with the two hillocks of dolerite now existing on the plain just behind Port Kembla (represented by 25-ft. contours on Fig. 1). Neglecting earlier fluctuations in sea-level, and considering only those of the most recent cycle, we find that some 25,000 years ago the sea-level was universally about 250 feet lower than at present, and that, up to about 3,000 years ago, a gradual eustatic rise occurred to a height some 15 feet above the present level.

[5] For the profile afforded from sea-level looking south-east, see Davis, 1936*a*, Pl. xii, 1.

Within the last 3,000 years the level has fallen some 15 feet (Daly, 1934). The application of these changes to the New South Wales coast is generally accepted.[6]

During the process of drowning, then, some 8,000–10,000 years ago, IV and V, at that time hillocks on the coastal plain, were severed from the mainland. The times of severance of I, II and III are more difficult to fix accurately, as moderately rapid erosion is still no doubt proceeding on the isthmus between I and II, and in the shallow water between II and III and between I and Red Pt. It is probable that drowning separated these islands about 4,000 years ago, and that during the 15-ft. fall in the last 3,000 years marine erosion has maintained the depth of intervening water, compensating for the falling level.

This sequence indicates that the islands have been continuously habitable for terrestrial communities such as occupy them at present, since the times of their separation from the mainland.[7] With sea-level 10–15 feet higher than at present (as at 3,000 years ago), V, in its present form, would be barely habitable, while the habitable areas of the other islands would be decreased. The probable decrease in the extent of the rocks forming the islands since the time of maximum sea-level would, however, allow V clearance above sea-level at all times sufficient to support terrestrial vegetation. This is supported by a consideration of the fauna of V, including lizards, Myriapods, etc. IV, though lower than V, would not be rendered uninhabitable by a rise in sea-level of 15 feet, even in relation to its present size, since it is more sheltered from heavy seas.

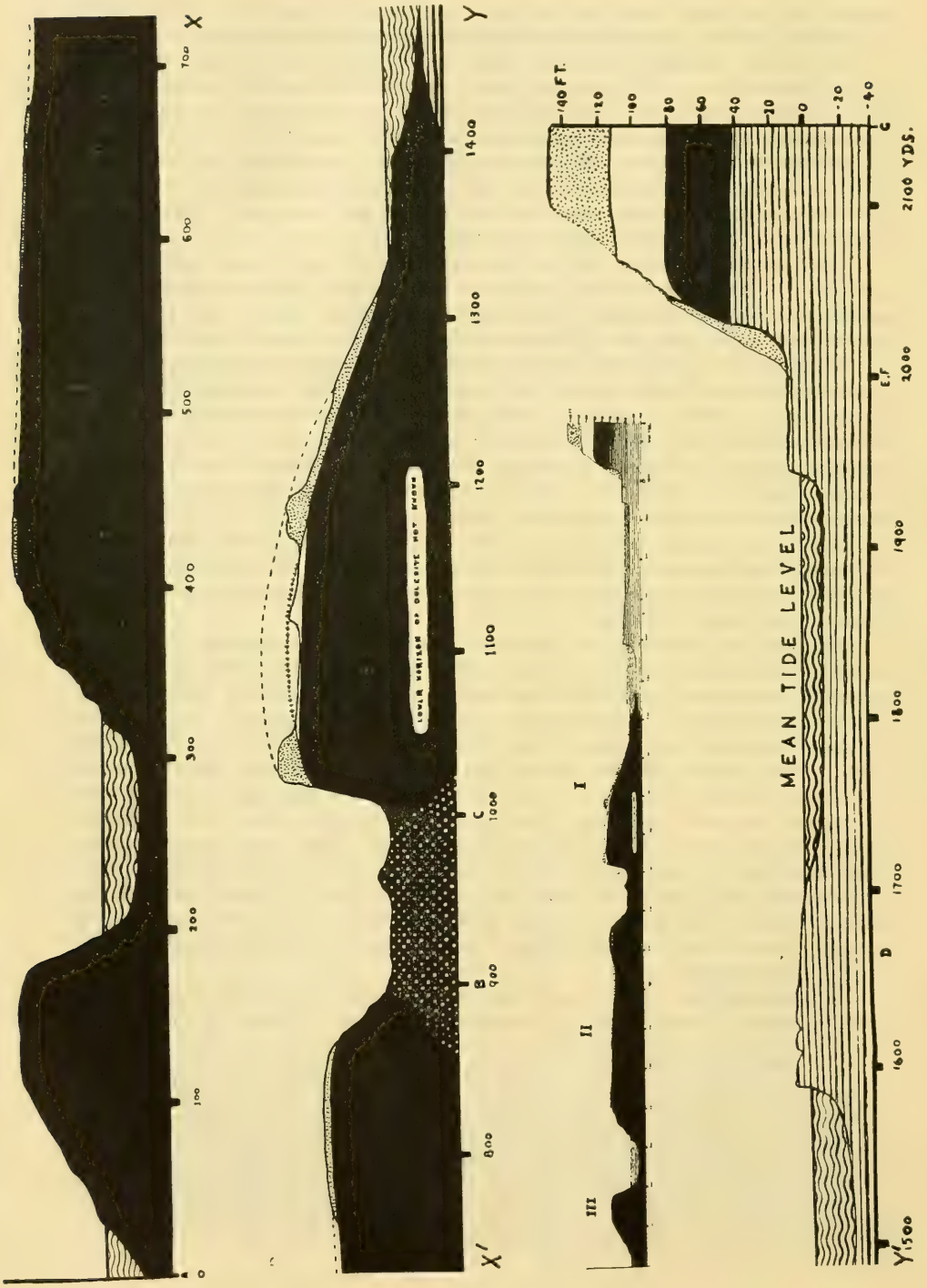
There is, therefore, no need to postulate that the native plants and wingless animals of the islands are other than relict from the time of severance, although it is possible that some are not lineal descendants of the population at that time, but are more recent colonists.

Prior to the drowning of the land around I–III, undulating sand-dunes, directly continuous with those now present on and to the south of Red Pt., probably covered this area. With the onset of drowning, most of this sand was washed away, leaving a thick cap on I and a thin covering on II (as indicated in Fig. 6, including the contour of the dotted lines), and cutting away the smooth slope of the dune on Red Pt., to give the present form. Below the level of the old dunes, usually at a depth of six feet or more, the sand was bound together to form a very soft sandstone. The binding substances appear to be hydrated oxides of iron, with little or no calcium carbonate. This recent sandstone may be regarded as a compacted illuvial horizon, the great porosity of the sand placing this horizon at a lower level than that normally found in other soils of this climatic zone, where podsols are the prevailing type. The recent sandstone is exposed in some places on the slopes of Red Pt., but is covered in most places by the loose sand talus.

In comparatively recent times, part of the sand covering of I and II has been removed by wind action, as indicated in Figure 6. Some of the sand so

[6] See also Cotton (1926).

[7] This probably applies to all the coastal islands of South-Eastern Australia. The claim that Lady Julia Percy Island, off the Victorian coast, is 'a pure volcanic mass uprisen in the sea, and not . . . a part of the old continental mass sundered from the mainland' (McCoy Society Report, 1937, p. 329) does not seem to be supported by any sound positive evidence. This island is separated from the mainland by about 4 miles of water, up to about 20 fathoms deep. To support the above claim, one must postulate a large and very recent uplift for this sector of the coast, or an improbably recent time for the vulcanicity responsible for the island rocks, with great subsequent reduction in the extent of the flows in a very short period.


X
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MEAN TIDE LEVEL
140 FT.
120
100
80
60
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20
0
-20
-40
1500
1600
1700
1800
1900
2000
2100 YDS.

Fig. 6.

removed is now present as bare drifts on the northern slopes of I (Pl. xvii, C), and as a drift, partly stabilized by plants, on its south-eastern slopes. The removal of this sand from II, where its former thickness was not great enough to lead to the formation of underlying sandstone, has laid bare the dolerite; on I the recent sandstone has been exposed. This has weathered to some extent, leaving an irregular surface with local elevations (Fig. 6; Pl. xvii, D). Erosion on the southern side of the exposed sandstone area of I has produced small ravines (Pl. xvii, E, F), revealing in a few cases an underlying heavy clay soil. This was probably derived from the dolerite, pre-dating the covering of this district by dunes. Its texture suggests that it is to be regarded as a 'Y' horizon,[8] the illuvial horizon of a pre-existing soil; the eluvial ('X') horizon has partly been removed by erosion, together with the overlying sandstone, partly become identified with the latter. This old soil is not represented in Figure 6, the sandstone probably resting direct on the dolerite on the section line. It seems to occur only under the southern part of the sandstone tract, where the pre-existing soil had evidently accumulated in a concavity in the surface of the dolerite. More of this clay horizon is continually being exposed by erosion following rain, small ravines cutting back into the 'blow-out' area due to the softer nature of the clay and consequent under-cutting of the sandstone. Both the clay of this 'Y' horizon and also the recent sandstone above it are unsuitable for plant growth, being hard and practically devoid of humus.

The cause and date of the 'blow-out' of the sand covering of I and II are somewhat problematical. The erosion of the underlying elements on I gives some evidence of the date, suggesting possibly several hundred years ago. The hummocks of sand on I are held in place by the introduced Buffalo Grass, and the sand-drifts on the slopes appear to be unstable and in the process of disappearance; but the tempting hypothesis that the 'blow-out' was caused, after the colonization of the islands by Buffalo Grass, by clearance of the stabilizing vegetation by rabbits, must be abandoned, because of the extent of erosion of the underlying formations and the fairly definite information of Port Kembla residents. We must assume that the 'blow-out' occurred before the advent of Europeans, and introduced plants and animals; that the hummocks of sand at the old level were held, at the time of 'blowing-out' of the surrounding sand, by indigenous vegetation (possibly *Sporobolus virginicus* and *Lomandra longifolia*); that this vegetation has now been largely replaced by Buffalo Grass, which has been able to cross the barren areas of exposed sandstone; and that the sand-drifts on the slopes are more stable than first inspection would suggest. The original 'blow-out' may have been caused by wind acting on sand whose vegetational cover had been disturbed by burrowing

[8] For the use of the terms 'X' and 'Y' horizon, see Macdonald Holmes, 1937.

Fig. 6.—Ideal section along line A-B-C-D-E, F-G of Fig. 1, V/H = 3/1. Camp Hummocks projected on section plane between C and D; section carried from E to a point of similar elevation and formation at F, to show formations behind F, which have been denuded behind E and would be omitted by a section continuing from D past E in a straight line.

The section is given in three pieces, X adjoining with X', Y with Y'. A small-scale reproduction of the whole section is given.

Horizontal shading, Upper Marine sedimentary rock; black, normal type of Dapto dolerite; white stippling on black, Dapto dolerite, Type B (see text); plain white, recent sandstone; black stippling on white, dune sand; undulating lines, ocean water; — — — — —, contour of old surface of dune, before 'blow-out'; + + + + +, contour of former upper horizon of recent sandstone, before weathering following 'blow-out' of dune.

marine birds; this process seems to be going on at present on parts of I where the sand cover is still present, and is detailed in the section on plant ecology.

III, IV and V show no indication of former sand cover. The soil of V is shallow and restricted to hollows in the rock on the higher parts of the island; that of III is fairly shallow, and confined to the upper portion of the western end. Both are derived from the dolerite, the latter with a slight admixture of sand particles, probably wind-borne. The plateau of IV possesses a good soil of fine texture, derived from the underlying trachy-andesite. It is at least two feet deep at the centre of the plateau, with definite podsolization, and becomes shallower towards the edge. Considering its size, the vegetation of IV is the richest of the group. This is doubtless attributable to better soil properties, the soil not being shallow and scarce, as on III and V, nor masked by poor dune soil, as on I and II. The shallow sand covering of II is probably in part mixed with soil originating from decomposition of the dolerite.

Climate.

Temperature, humidity and rainfall data for Wollongong have been given by Davis (1936*b*). The averages are: Maximum daily temperature 71·4° F.; minimum daily temperature 54·6° F.; relative humidity 73%; annual rainfall 45·65 inches. The rainfall at the islands is probably somewhat less than at Wollongong. Our observations indicate that the islands miss many showers which strike Wollongong and other points on the coast, and this is supported by theoretical considerations. The mountains behind Wollongong, and behind the coastal plain in general, precipitate the rain, and proceeding east from these mountains to Wollongong there is an observed drop in rainfall, which is probably continued seawards from the coast.

The temperatures detailed are shade temperatures. The terrestrial life of the islands is subjected to much greater extremes. Our observations indicate that the daily range in exposed situations such as the more open parts of the *Scirpus nodosus* community on I may be very considerable.

All the islands are very exposed to winds, V most and IV least so. The question whether this justifies the recognition of shrub communities as a climatic climax for the islands is dealt with in a subsequent section. In rough weather, salt spray is driven over all portions of the islands. We have observed fine spray drifting across the highest point of the islands (High Hummock, I, 71 ft.) in moderately rough weather; at this time, heavy spray was being driven over the whole of II and III, while V was subjected throughout to very heavy spray. Relatively high chloride contents were observed for all soils, particularly poorly-drained soils with little leaching. All plants on the islands must be considered halophiles to a greater or less degree; a large number are common to the islands and to the saline swamp vegetation of the Sydney district described by Hamilton (1919). The effects of spray on all pool communities on the islands is discussed later.

Plant Ecology.

In Table 1 are listed the various species of vascular plants observed, with notes on frequency on each island, life-form, and usual habitat. For purposes of classification we have recognized the following communities: (1) The *Correa-Westringia* Community; (2) The *Stenotaphrum* Community; (3) The *Sporobolus* Community; (4) The *Scirpus nodosus* Community; (5) The *Mesembryanthemum* Community; (6) The *Lomandra* Community; (7) The *Salicornia* Community; (8) The *Spergularia–Claytonia–Portulaca* Community; (9) The *Scirpus cernuus* Community.

This classification includes under the term 'Community' widespread aggregates such as the *Stenotaphrum* or *Correa-Westringia* communities, and small local groups such as the *Scirpus cernuus* community. Communities (6) to (9) might better be termed 'societies'. We have purposely omitted terms such as 'consociation' and 'consocies', with their successional implications; the shrub community (*Correa–Westringia*) is the highest on the islands, but even it is to be regarded as a subclimax. Certain communities (e.g., *Mesembryanthemum aequilaterale* on almost bare rock) can be regarded as seral (stages in a lithosere of which placoid lichens are the initiators); but, as, on the whole, the vegetation is in a retrograde state, due to the gradual marine erosion of the islands, etc., we do not consider that upgrade succession is proceeding to any marked extent. Apart from retrogression by marine erosion, the vegetation is in a highly unstable state, chiefly due to disturbance by man, introduced animals and plants, and burrowing sea-birds.

Plate xv*a* shows the distribution of the communities, with the exception of the *Scirpus cernuus* community, which occupies a small area on I and II, fringing the lower limit of other communities in some parts, especially along the southern side. The habitat factors of the various communities are considered as each is dealt with, but the relations of *Stenotaphrum*, *Sporobolus* and *Scirpus nodosus* may be discussed here. Plate xv*a* shows the presence of *Scirpus nodosus* community on the central part of I and a small portion of II, in those parts where the sand cover has been removed, exposing recent sandstone, hard clay, or (on II) dolerite, as detailed earlier. In the areas of sand remaining, the chief stabilizing agents are the grasses *Stenotaphrum* and *Sporobolus*. The former is introduced, the latter indigenous. The transparency (Pl. xv*a*) suggests that *Stenotaphrum*, probably introduced to the inner (western) side of I, the usual place of landing and residence by visiting parties, has displaced *Sporobolus* on I (except for a remnant on Periwinkle Pt.), and over the inner end of II. Whether this displacement is still proceeding at the ecotone cannot yet be stated with certainty; *Stenotaphrum*, however, became more prominent on II, between its eastern limit as marked on Plate xv*a*, and Triangle Pool, between August, 1937 (when the transparency was prepared), and April, 1938, and in July, 1938, appeared to be further spreading in this region at the expense of the *Sporobolus* community.

Vegetation (*Stenotaphrum* community) reaches a point slightly below the 10-ft. contour behind the beach, on I (Pl. xvii, J), the spot most sheltered from rough seas on any of the islands. Elsewhere, the lower limit of vascular plants is much higher, on I and II between 10 and 20 feet, on the western extremity of III 20 feet, and elsewhere on III 30 feet. Only a few therophytes occur below 20 feet on IV, the entire northern rock-platform being devoid of vascular plants except a few specimens of *Sonchus oleraceus*. On V, most of the vascular plants occur above the 40-ft. contour, 30 feet being the lower limit, except on the north-west corner, where more efficient shelter from south-easterly seas allows them to reach a slightly lower level.

The Correa–Westringia Community: A shrub community 3–4 feet high is developed over extensive areas of II, at the north and south ends of the plateau of IV (a few bushes also on the eastern slopes, IV), for a limited area on the slopes of the western end of III, and, as a few isolated bushes, on the north side of I. The shrubs occur only on well-drained soils, usually not less than six inches in depth. They do not seem to be limited in any way to situations sheltered from the wind. The properties of three typical soil-samples from this community are given in Table 2. The absence of shrubs from the central part of the plateau of IV cannot

be explained satisfactorily. The salinity (as indicated by chloride content) is higher in the central part of the plateau, due to the run-off of water from the slightly higher parts at the north and south ends; the humus content is lower, and the pH higher. The humus content of soils in the shrub community, however, is a direct result of the conditions below the shrubs, where many fallen leaves accumulate. Similar conditions on the margins of the shrub community, where there is cover by branches but absence of rooted plants, should allow the community to spread if humus content alone were the limiting factor in shrub distribution. Neither high salinity nor high pH (a result of high salinity and low humus content) can be limiting, as the figures for a shrub community from II are higher than for soil from the centre of the plateau. No young shrubs have been present at the margins of the community on the plateau at any time since our observations commenced; indeed, some of the older bushes were wholly or partly dead (March, 1938), possibly from severe wind action, possibly from infestation by scale-insects. The factors limiting shrub distribution are not known. The burrowing activities of penguins and mutton birds adversely affect the stability of certain communities on I and II, but, in general, these birds burrow in the more open communities rather than amongst shrubs. However, some of the marginal shrubs bordering the *Mesembryanthemum* community on IV were partly undermined by penguin burrows in July, 1938, and this may possibly have an adverse effect on the roots, promoting the limitation and destruction of the shrubs at and near the centre of the plateau.

Correa alba is dominant in most parts of the shrub community of II, *Westringia rosmariniformis** seldom becoming dominant or co-dominant (Pl. xvii, G). On the plateau of IV, *Westringia* and *Correa* are co-dominant, or each attains local dominance in some areas (Pl. xvii, H), while *Myoporum ellipticum* occurs occasionally, attaining dominance in a small area near the western edge of the plateau (Pl. xvii, I). In the shrub community of III, *Correa* and *Myoporum* are co-dominant, *Westringia* absent.

On I, in the few places where shrubs develop, *Westringia* is the dominant.

The shrub communities of I and III were probably of greater extent before the advent of Europeans and the introduction of exotic plants. *Opuntia inermis*, when unchecked, grows strongly amongst the shrubs on III and parts of II. The fluctuations of *Opuntia* are discussed more fully under the *Stenotaphrum* community.

In its undisturbed state, the *Correa–Westringia* community is practically devoid of other plants. Neighbouring communities, such as *Sporobolus* on II and *Mesembryanthemum* on IV, may enter the shrub community marginally as a ground layer, and occupy the areas between the scattered bushes. In most cases, however, the shrubs grow close together, and the ground below them is devoid of any other vegetation, probably because of lack of light and the presence of an A_0 horizon of fallen leaves, an obstacle to seedling germination. On IV the climber *Kennedya rubicunda* occurs scrambling over the shrubs.

The Stenotaphrum Community, with variant facies: The introduced Buffalo Grass (*Stenotaphrum secundatum*) is dominant on sandy areas over a large proportion of I and the western end of II; it also occurs on V in shallow soil in rock crevices, not reaching the status of a community. It has recently (since 1934) colonized IV, being well established on the eastern slopes and plateau in March, 1938.

* Since the completion of this paper, Mr. E. Cheel has recorded *Westringia fruticosa* Druce as the correct name for the species cited in this paper as *W. rosmariniformis* Sm. (Abstract, Proc. Linn. Soc. N.S.W., 31 Aug., 1938.)

The properties of soil samples from four parts of this community are given in Table 2. In Table 3 is indicated the effect of nesting of sea-birds on the nitrogen and phosphorus content of soil from this community; nitrate and ammonia content is raised, phosphate apparently not. This increase in combined nitrogen appears to have little effect on the vegetation.

The grass often reaches a height of 1–2 feet. During our earlier visits (1934–5), *Opuntia* and *Stenotaphrum* were competing for dominance in those parts of I and II where the latter is now dominant (as shown in Plate xv*a*). The two species were growing up, sometimes above three feet in height, the lower layers with a large percentage dead from lack of light, the *Stenotaphrum* tending to gain the advantage in the struggle for light, except in the more open parts, where the plants were disturbed by penguin burrows. *Opuntia* is a wide, occurring in all the communities of well-drained soils (particularly the *Sporobolus* and *Correa-Westringia* communities) and on almost bare rock. During our earlier visits it appeared to be becoming dominant in all the more open places. Particularly since 1935, officers of the Prickly Pear Destruction Commission (N.S.W. Department of Lands) have taken measures to eradicate the *Opuntia*, because segments of the cladodes were breaking off, falling into the sea, and so being carried down the coast to infect farms on the mainland to the south of the islands. This colonizing ability indicates how *Opuntia* originally reached the islands.

Opuntia has been attacked by the introduction of the eggs of the moth *Cactoblastis cactorum* Berg.; by poisoning with arsenic; and by fire. It has never been exterminated completely, as the attempted eradication measures have been somewhat sporadic, and from time to time it becomes fairly abundant. It is to be regarded as a widespread facies in most communities (especially *Correa-Westringia*, *Stenotaphrum*, *Sporobolus*, *Scirpus nodosus* and *Mesembryanthemum* communities), varying sporadically on account of the biotic factor of human interference (Pl. xviii, C, D, E).

The *Stenotaphrum* community has two other notable facies, those given by *Phytolacca octandra* and *Tetragonia expansa*. The former occupies large areas of the *Stenotaphrum* community to the north and west of I, and is a seasonal facies, *Phytolacca* being an annual. The *Tetragonia* facies is represented by a moderate area behind the beach on I, and a small area on the southern side of the west end of II. *Tetragonia* grows as a perennial on the islands, and in places occurs as an almost pure stand, with very little *Stenotaphrum* admixed. The humus content appears to be higher in the *Tetragonia* facies than elsewhere in the *Stenotaphrum* community.

Other elements of the *Stenotaphrum* community are of rarer occurrence. We have considered as a separate community *Lomandra longifolia*, which may occur alone or with *Stenotaphrum*, as at Camp Hummocks, I (Pl. xvii, A). *Phragmites communis* grows amongst *Stenotaphrum* in the southern portion of I, especially near Phragmites Soak (Pl. xix, G), in most cases in soil more efficiently drained than in its mainland habitats. *Imperata cylindrica* var. *Koenigii* and *Setaria glauca* occur in the *Stenotaphrum* community behind the beach, I, the latter as a seasonal facies. Other elements can be found by reference to the last column of Table 1, in most cases being straggling plants (e.g. *Hibbertia volubilis*, *Commelina cyanea*, *Kennedya rubicunda*), or small herbs, often annual (e.g. *Anagallis arvensis*, *Solanum nigrum*, and many Composites). The bracken (*Pteridium aquilinum*) occurs occasionally in this community.

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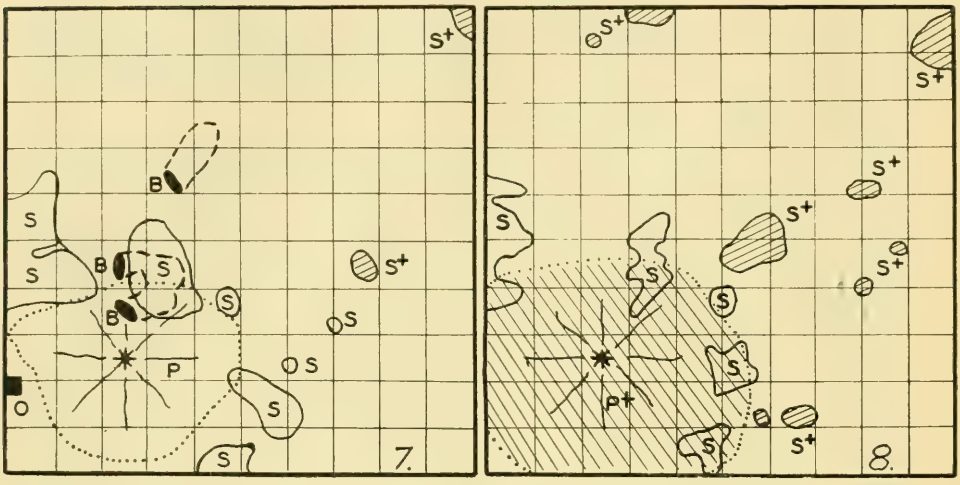

Figs. 7 and 8.—Permanent quadrat in *Stenotaphrum* community between beach and Camp Hummocks, I. Area disturbed by burrowing activities of penguins and mutton-birds. Fig. 7, 18/12/37; Fig. 8, 24/4/38. Side of quadrat 10 ft. (see also Pl. xviii, A and B). Orientation: North side to the left.

(S, *Stenotaphrum secundatum,* living; S+, do., dead; P, *Phytolacca octandra,* living; P+, do., dead; O, *Opuntia inermis*; B, burrow. The shading indicates dead plants; *Phytolacca* is represented by an asterisk for the main stem, and a dotted line for the limit of branches. Mouths of burrows represented by black ovals, the limits of the underground portions by broken lines.)

Figures 7 and 8 represent a permanent quadrat in portion of the *Stenotaphrum* community behind the beach, I, where nesting sea-birds have disturbed the soil with their burrows. Figure 7 represents the quadrat on 18.12.37, Figure 8 on 24.4.38. Photographs of the quadrat on these dates are given in Plate xviii, A and B. In these four months, disturbance by burrowing allowed the wind to remove a thickness of two inches from the surface of the sand. This has undermined the *Stenotaphrum*, in parts killing it and thereby further hastening the process of wind erosion. In Plate xviii, B and C, the seasonal change of the *Phytolacca* facies is also visible.

The Sporobolus Community: This community, dominated by *Sporobolus virginicus*, occupies most of the eastern end of II wherever shrubs are not developed, a great proportion of the area of III occupied by vascular plants, and the higher parts of Periwinkle Pt. on I. It occurs in dry soil, or in water-logged soil lying in rock hollows; in sandy soil, or soil derived from igneous rock. The dominant has a high salt-toleration. Properties of soils from four parts of this community are listed in Table 2. In the wetter parts of this community, elements of the *Scirpus cernuus* community (detailed later) sometimes occur; in its drier parts, in addition to *Opuntia*, several small herbaceous species, which may be found by reference to the last column of Table 1, are occasionally present. *Zoisia macrantha* occurs in most parts of this community, and is difficult to distinguish from *Sporobolus* in the absence of inflorescences. Identification on characters of the leaf anatomy has shown that *Sporobolus* is always dominant, as is also indicated by a study of the inflorescences when available. The community is shown in Plates xviii, F, and xix, C.

The Scirpus nodosus Community: This community occupies those areas of I and II from which the sand cover has been removed. The plants grow in small accumulations of sand, 1–2 inches deep, collected round the tussock bases. The properties of soil samples from two localities are given in Table 2. In some places the plants are very widely spaced (Pl. xvii, B and D); but in the neighbourhood of shifting sand which can readily collect round the tussocks, as around High Hummock, a dense stand is formed (Pl. xviii, G). Few other elements enter this community, which occupies a very unfavourable habitat: a few plants of *Inula graveolens*, *Mesembryanthemum aequilaterale*, *Enchylaena tomentosa*, *Salsola Kali*, and very rarely *Phytolacca octandra* on I, and of *Tillaea Sieberiana*, *Dichondra repens* and *Cyperus polystachyus* on II.

Scirpus nodosus occurs occasionally on small accumulations of soil on rock on I and II, apart from the 'blow-out' areas, and in the *Mesembryanthemum* community on the plateau of IV.

The Mesembryanthemum Community: Small patches of *Mesembryanthemum aequilaterale* occur on all the islands on rock surfaces almost devoid of soil. Forward succession in time, by the colonization of rock surfaces by this species, has not been observed; it may possibly be going on in isolated cases, since equilibrium does not necessarily obtain at present at the lower limit of vegetation. On III this species forms a definite community in shallow soil on the upper part of the island, surrounded by the *Sporobolus* community. The community reaches its greatest development on those parts of the plateau, IV, on which no shrubs occur; in this situation the mat is mingled with other species, and does not form a pure stand as elsewhere.

As recently as March, 1936, the centre of the plateau of IV was clothed with a mixed community, in which *Stephania hernandifolia* was the commonest species, with *Plectranthus parviflorus*, *Kennedya rubicunda*, *Dichondra repens*, *Senecio lautus*, and several other species admixed (Pl. xviii, I). By March, 1938, all of this area was covered by a mat of *Mesembryanthemum aequilaterale*, with other species (*Stephania*, *Plectranthus*, etc., and *Lepidium hyssopifolium*) occupying a very subsidiary rôle (Pl. xviii, J). We cannot satisfactorily explain this replacement of one community of endemic plants by another of equal or lower integration; however, it was noted in July, 1938, that the mixed community showed some evidence of becoming re-established in a few parts of the centre of the plateau, where the *Mesembryanthemum* mat had been disturbed by burrowing penguins.

Properties of soil samples from two parts of the *Mesembryanthemum* community are given in Table 2, one for the community of the centre of the plateau, IV, the other for shallow soil collected around *Mesembryanthemum* on otherwise bare rock, IV. The latter has a high organic content, suggestive of a stage of a lithosere. In all cases, the situations where this community occurs are well drained.

The Lomandra Community: *Lomandra longifolia* occurs on dune sand, as isolated small hummocks holding the sand at the old level in the 'blow-out' area, on the north side of I (Pl. xvii, B), and, with or without *Stenotaphrum*, on the larger hummocks (Camp Hummocks) in the centre of I (Pl. xvii, A). Properties of soil from the latter situation are given in Table 2 (fourth sample under *Stenotaphrum*). Except for the occasional admixture of *Stenotaphrum* at Camp Hummocks, *Lomandra* forms a pure stand, no other species occurring in this community. On II, *Lomandra* is rare, not forming a definite community.

The Salicornia Community: This community is confined to a hollow on the south side of III, in shallow poorly-drained soil with high salt-content. *Salicornia australis* forms a pure stand, bordered by the *Sporobolus* community on the upper side, where drainage conditions are better (Pl. xix, A). The properties of two soil samples from this community are given in Table 2.

The Spergularia–Claytonia–Portulaca Community: This term has been applied to the vegetation occurring on shallow poorly-drained soils in rock basins on the eastern slopes of IV; similar aggregations occur on the higher parts of V. *Portulaca oleracea* (Pl. xix, B) is the commonest species, but is an annual. Other elements (perennial) are *Claytonia Pickeringi*, *Spergularia rubra*, *Cotula coronopifolia* and *Mesembryanthemum australe*. The species may occur singly or in various combinations. Properties of soil from a typical example of this community are listed in Table 2.

The Scirpus cernuus Community: This term is applied to those aggregates occurring in poorly-drained situations in the lower parts of I and II (Pl. xix, H). *S. cernuus* is often associated with *Samolus repens*, *Apium prostratum* and *Lobelia anceps*, any of which may also occur separately in similar situations. *Samolus* and *Apium* also occur in the moister parts of the *Sporobolus* community.

Soil properties for two parts of this community are listed in Table 2. In some respects, this community corresponds to the *Spergularia–Claytonia–Portulaca* community of IV and V, and the *Salicornia* community of III, but the salt-content appears to be much lower, the highest content being found in soils of the *Salicornia* community. These three communities, however, stand apart from the other communities recognized, in being communities of poorly-drained soils. *Sporobolus* stands in an intermediate position between these three and the remainder in that it tolerates a variety of drainage conditions.

Life-Form Spectra: Table 4 gives life-form spectra (Raunkiaer, 1934) for indigenous and total species for the Five Islands, as a whole and for individual islands. I and II are considered as a single unit. The spectra for Brush Island and for an area of the *Eucalyptus pilularis* association are given for comparison, as well as the 'normal' spectrum. Brush Id. is situated close to the mainland some 75 miles south of the Five Islands, and is composed of augite–olivine–monzonite with a complete dune cover, similar to that which must have been present on I before the 'blow-out' occurred. Its greater area and height, and deeper soil, offer more favourable conditions for plant growth than any on the Five Islands. It possesses 66 species of vascular plants, of which 38 are common to the Five Islands. The *Eucalyptus pilularis* association is given as a typical forest climax on good soil in the same climatic zone as the Five Islands.

It must be remembered that life-form spectra were originally derived for comparing climax vegetations of different climatic zones, although later applied by their originator to local communities other than the climax within one climatic unit. In the present case the spectra are adduced to compare the characteristics of the flora of the islands *inter se* and with other communities, to show correlation with soil formation, shelter, etc. No allowance is made for specific frequency, each species (whether rare or dominant) counting one point; this is the usual procedure, but is not by any means ideal. Again, it is somewhat difficult to apply a terminology based on perennating buds in a climate where most species (except, of course, the therophytes) continue growth at all seasons.

The Five Islands are devoid of phanerophytes other than nanophanerophytes, even these being poorly represented, and more by herbaceous and climbing types than woody shrubs. V, with little soil, and very exposed, has no woody nano-

phanerophytes. The chamaephyte figure is high in all cases; hemicryptophytes are average, geophytes very rare. Therophytes are well represented, and the effect of the introduced element in raising the therophyte percentage is at once apparent. This is due partly to coincidence; many of the introduced species are Composites, which have wind-borne fruit suitable for the colonization of islands, and, as an entirely independent character, happen to be therophytes. In general, introduced species established on the mainland are largely therophytic, being plants able to avail themselves of rapidly-changing areas of disturbance. The only stem-succulent on the islands is also introduced.

We regard the shrub communities of the Five Islands as a subclimax, not as a local climax under the special climatic conditions of the islands. Brush Island, with almost identical climatic conditions (wind exposure, etc.), develops a low forest of *Banksia integrifolia* Linn. f. and *Casuarina glauca* Sieb. The lack of trees on the Five Islands is therefore attributed to lack of suitable soil conditions rather than to an unfavourable climate; climatically, the shrub communities are a subclimax, the climax not forming because of unfavourable edaphic conditions. In addition to microphanerophytes, Brush Island possesses one epiphytic species (*Platycerium bifurcatum* (Cav.) C. Chr.).

The vegetation of the Five Islands and Brush Island, and especially the facts given by the life-form spectra, may be compared with the data given by Osborn (1922, 1923, 1925) for islands off the coast of South Australia.

Introduced Plants: In Table 5 are given the numbers of introduced species recorded from the Five Islands (individually and collectively) and from Brush Island. In addition, the proportion of introduced to total species is given as a percentage. Both figures must be considered for comparative purposes, the percentage reflecting the effect of the habitable area of each island, and the consequent probability that seeds will reach land, and germinate once they have done so. The low figures for Brush Island are due chiefly to the relatively undisturbed nature of the adjacent mainland, and the rarity of visits by man. Brush Island is in a position relative to the nearest point of the mainland comparable to that occupied by I. The number of introduced species of plants growing on the mainland in the settled areas near Port Kembla is considerable.

The only introduced species at the Five Islands which are not therophytes are *Opuntia inermis* (stem-succulent) and *Stenotaphrum secundatum* (chamaephyte).

Crossing from the mainland to the islands was accomplished in half the species (9 out of 18) by wind-borne fruit, while two species (*Phytolacca octandra*, *Lycium ferocissimum*) have fleshy fruits. Ground-larks (*Anthus australis*), part of whose diet consists of seeds, are found commonly on I, II and III, and have frequently been observed flying between II and III, and occasionally between I and the mainland. These birds have not up to the present been observed on IV and V, but probably fly there on some occasions.

The observed ability of *Opuntia* to recolonize mainland areas by its cladodes, floating from the islands in the open sea, explains its original invasion of I, II, III and IV, without the necessity of invoking its fleshy fruit as a means of entry; however, officers of the Prickly Pear Destruction Commission have observed crows (*Corvus coronoides*) feeding on *Opuntia* fruits at the islands.

Of the remaining introduced species, *Stenotaphrum* was probably introduced to I, and possibly to II, by man, but its occurrence on IV and V cannot be so explained. On I, its stolons frequently hang down over rocks in long festoons (Pl. xix, J), and the colonization of IV and V is probably due to the carriage of these vegetative

parts by sea;[9] carriage of the seeds by birds is less probable. *Atriplex patulum*, which was observed near the beach on I in 1934, but now seems to have died out, was probably introduced by man. *Rumex crispus*, a recent migrant to IV, has a swollen, buoyant anthocarp, which may have floated from the mainland. *Datura Stramonium*, with a large, buoyant capsule, is a recent migrant to I, growing just behind the beach, whither its fruits were probably carried by sea. *Anagallis arvensis* (on I, II, and also on Brush Island) may have been introduced as seed by birds, or may have reached I and II with the introduced mammals. *Malva parviflora*, an introduced species on V, possesses a thin mericarp, which might possibly have floated to the island or have been carried by westerly winds.

Other species which may be indigenous, or may have reached the islands by recent colonization, are *Solanum nigrum*, with a fleshy fruit (on I, II, IV, V, and on Brush Island, where *S. laciniatum* Ait. falls within the same category); *Rumex Brownii* (near the beach, I), with a burr fruit, such as would be carried on human clothing or the hair of introduced mammals; and *Echinochloa crus-galli*, the fruit of which might be eaten by birds, and so carried to V. *Lepidium hyssopifolium*, indigenous in New South Wales, has become increasingly numerous on IV during the last few years, suggesting that it may also be a recent migrant to the islands, possibly as seeds eaten by birds.

Pumpkin, tomato and potato plants, introduced by man, have been observed on I near Camp Hummocks. They have never become properly established, only the first-named showing any evidence of doing so. They have been omitted from Table 1, and from the calculations by which Tables 4 and 5 were derived.

Interaction with Extraneous Communities.

Interaction with Mainland Communities: Under this heading comes the disturbance of the ecological equilibrium effected by introduced plants. Their means of entry and behaviour on becoming established have already been discussed. The process is probably still continuing. The remaining interactions may be listed as follows: (A) Introduced animals which have become established on the islands, and now form an integral part of the island life; (B) Animals coming to the islands as temporary but regular visitors, and definitely entering the island food-chains; (C) Animals reaching the islands by chance, of irregular and transient occurrence. (B) and (C) are concerned chiefly with species indigenous in this region.

(A).—1. The introduced fly *Lucilia sericata* Meig. is common on I; the journey from the mainland is well within its normal flight range.

2. The introduced scale-insects *Saissetia oleae* Bern. and *Ceroplastes destructor* Newst. are established on the islands, the former on I and II, the latter on IV. This invasion is possibly to be attributed to the minute first-instar larvae being carried by strong westerly winds.

3. As noted earlier, goats and rabbits were introduced by man many years ago. The latter are established as a definite part of the biome; the former became extinct only by interference from without.

4. The moth *Cactoblastis cactorum* Berg. has been introduced to I by officers of the Prickly Pear Destruction Commission. It has become well established, and has spread to IV, apparently by its own powers of flight.

[9] Stolons of this type, lacking roots, were immersed in sea-water for 18 hours, exposed without soil or water for 14 days, and then placed in moist sand. Within a further 14 days adventitious roots and new leaves were formed.

(B).—1. Human beings disturb the balance of the biome by killing members of the animal population, and add to the islands additional habitats in excreta and discarded food. The human factor pre-dates the advent of Europeans, as is indicated by an aboriginal midden, with discarded flints and large shells, on I (Pl. xvii, D). This may pre-date severance of the island from the mainland, but not necessarily so, as in Cook's journal there is a reference to canoes used by natives in this locality.

2. Ground-larks are probably the only land-birds nesting on the islands. Birds of prey, such as the Nankeen Kestrel (*Cerchneis cenchroides*), derive much of their food supply from the islands, but are not continuous residents. The Boobook Owl (*Spiloglaux novae-seelandiae*) has been observed on I and II, where it rests by day in holes in steep rock-faces, and hunts at night, flying also to IV. It is reasonably certain that it does not nest at the islands. Swallows (*Hirundo neoxena*) are frequently seen hawking over I and II, but have not been observed to breed there; they have been seen flying between I and the mainland. Quail (*Ypsilophorus ypsilophorus*) occur rarely on II, probably seasonally, as on Brush Island. The Black-and-White Fantail (*Leucocirca volitans*) and Silver-Eye (*Zosterops lateralis*) occur, the former having been observed frequently on I, II and III, the latter rarely on I. These birds may possibly breed at the islands, but this has not been observed. In all the above instances, and in the case of the ground-larks breeding at the islands, interaction occurs between the islands themselves, in addition to interaction with the mainland.

3. Odonata (Anisoptera and Zygoptera) have been observed on III, where no breeding habitat exists; these individuals probably developed in Triangle Pool, II. Anisoptera have been observed on IV, where there does not appear to be any breeding habitat; these individuals were probably from the mainland. In fact, it is possible that all the islands are visited by Odonata from the mainland.

4. Although there are no nests on the islands, bees (*Apis mellifera* L.) have been observed on several occasions on IV, gathering nectar from flowers (particularly of *Plectranthus parviflorus*) on the plateau. This is probably a regular occurrence. This example is included here, rather than under (A), although *Apis* is introduced.

(C).—The butterfly *Tisiphone abeona* Don. has been observed on IV, although its food-plant (*Gahnia*) does not occur on the Five Islands. Cicadas (e.g., *Thopha saccata* Fabr.) have also been observed to fly from Red Pt. to I, and have been observed on III following westerly winds. These and other winged insects are irregular visitors to the islands, possibly entering the food-chains, although not in the regular manner comparable with the instances under (B).

Interaction with Marine Communities:

(A).—The following marine birds breed at the Five Islands: The Little Penguin (*Eudyptula minor*), very common on I and II, occasional on III, and IV and V; the Wedge-Tailed Shearwater or Mutton-Bird (*Thyellodroma pacifica*), very common on I, occasional on II and III; the Silver Gull (*Bruchigavia novae-hollandiae*), common on III and probably on V; the White-Faced Storm Petrel (*Pelagodroma marina*), fairly common on II; the Black Oyster-Catcher (*Haematopus ostralegus*), rare on IV; and the Red-Capped Dotterel (*Leucopolius ruficapillus*), rare on I. The last species nests in the more open parts of the *Scirpus nodosus* community on the 'blow-out' area of I, where it may possibly derive some of its food from terrestrial sources. The Crested Tern (*Thalasseus bergii*) is common near the islands, in some years nesting on III, and possibly on V (although we have not been able to land on this island during the breeding season).

The effect of these birds in raising the combined nitrogen in the soil is shown in Table 3. Little effect of the increased nitrogen content on the vegetation can be noticed; *Stenotaphrum* is somewhat more robust than in most mainland situations, but the burrowing activities of *Eudyptula* and *Thyellodroma* more than counteract any benefit the vegetation might receive from the sea-birds. On Brush Island, the creeper *Kennedya rubicunda* develops leaves several times the size of those of plants from other localities. This may be a result of the manuring of the soil by birds. The excreta of birds also raise the phosphate and nitrate content of pool waters, favouring protophyta, the base of some pool food-chains.

The sea-birds, especially those forming burrows, provide a habitat for nest-parasites (Siphonaptera, etc.), whilst lizards (*Lygosoma* spp.) frequently use empty nests as retreats. The ticks *Ornithodorus* and *Ixodes* are true ectoparasites when the birds are present on the islands, at other times resting on and under rocks (IV, V); at this stage they are occasionally eaten by lizards. The sea-birds also appear to form part of the diet of birds of prey; on Brush Island we observed several crows (*Corvus coronoides*) feeding on a freshly-killed Little Penguin, and on Lady Julia Percy Island the Swamp Harrier (*Circus juxta*) is recorded as feeding on mutton-birds during the breeding season (McCoy Society Report, l.c., p. 429). Both *Corvus coronoides* and *Circus juxta* occur frequently on the Five Islands (I–III), but we have not observed this feeding-habit there. However, many sea-birds have been seen dead on the higher parts of I, II and III, probably from this cause. Dead sea-birds also enter terrestrial food-chains as the habitat of carrion insects (Muscoid flies, Histeridae, Staphylinidae, Dermestidae, etc.).

(B).—Two species, the Marine Caddis-Fly (*Philanisus plebejus* Walk.) and the Marine Tipulid (*Limonia* (*Dicranomyia*) *marina* Sk.) occur on the Five Islands, the larvae feeding on algae in the littoral zone, the adults being terrestrial. Adults of *Philanisus* have been taken as far from the shore as Camp Hummocks, in the centre of I. Both species almost certainly enter terrestrial food-chains.

(C).—Insects, particularly Muscoid flies, both larvae and adults, are found on carrion of marine origin about the high-tide mark, especially on the beach, I. Muscoid larvae have been recorded living in dead pieces of the Ascidian *Cynthia* on the beach, I, well below the high-tide mark. The adults of these species certainly enter terrestrial food-chains; lizards (*Lygosoma* (*Hinulia*) *quoyi* Dum. et Bibr.) frequent the zone behind the beach, I, feeding on adult flies, and the Black-and-White Fantail has been observed feeding on flies between tide-marks on the beach.

(D).—Insects, particularly Coleoptera such as Staphylinidae, and Diptera (Phycodromiidae, Anthomyiidae, etc.), have their habitat in aggregations of dead kelp (*Ecklonia*) washed up at the extreme limit of waves, especially on the isthmus between I and II and on the northern rock-platform of IV. These insects form a separate community, which is linked with typically terrestrial communities by spiders which at times frequent it. The habitat of Machilids (*Allomachilis froggatti* Silv.) on IV contains vegetable detritus of terrestrial and marine origin (dead leaves of *Kennedya*, etc.; dead coralline sea-weed, etc.), and either or both may form the food of the Machilids.

(E).—The common littoral crab *Leptograpsus variegatus* (Fabr.) is frequently found in pools above the reach of waves, including those of low salinity (e.g., Triangle Pool). Specimens of this crab have been collected in pools 45 feet above mean tide level on III, with insect remains (larvae and pupae of *Aedes* (*Pseudoskusea*) *concolor* Tayl., and larval Chironomidae) in the crop.

(F).—The periwinkle *Nodilittorina tuberculata* (Menke) occurs on rocks 40 feet and more above mean tide level, both on dry rock-faces and in pools, particularly on Periwinkle Pt., I. *Melarhaphe unifasciata* (Gray) occurs at slightly lower elevations. Marked specimens of *Nodilittorina* remained at about 40 feet above mean tide level on I from August, 1937, to July, 1938, only a small percentage showing any tendency to migrate seawards. This species was observed copulating on rocks 25 feet above mean tide level on IV (March, 1938). It probably derives its food from the zone where it occurs most frequently. The rocks there are covered with placoid lichens, and the periwinkles may possibly feed on these, or on detritus in rock pools. Periwinkles do not appear to act as food (as carrion or otherwise) to any extent for terrestrial animals, so that, even if they derive food from terrestrial sources, the food-chain is a 'blind' one.

Animal Habitats.

From the point of view of animal ecology, each plant community, or for phytophagous species each plant species, may be taken as the habitat unit, and this can be further subdivided. Thus *Correa alba* offers at least five different habitats: (1) The leaves, accommodating leaf-eating beetles, leaf-miners, etc.; (2) the flowers, the habitat for thrips, etc., as well as for nectar-feeders paying occasional visits; (3) the stems, the habitat of Coccidae; (4) the accumulation of dead leaves (A_o horizon) on the soil surface, the habitat of Blattidae, Embioptera, etc.; and (5) the underlying soil, where earth-worms, etc., may occur. Carnivorous species, however, especially birds and winged insects, cannot be assigned to any such community, but are wides ranging through many plant communities, and elsewhere.

It would be superfluous to enumerate all the situations, comprised in the communities of vascular plants, which form habitats for animal communities on the islands; below are enumerated those habitats of terrestrial animals (as opposed to marine) which are not included in vascular plant communities.

(1) *Pool habitats*:

(*a*) *Triangle Pool* (Pl. xix, D): This is the largest pool (other than strictly littoral pools) on the islands; it is some 10 yards long, of varying width, and up to about three feet deep. Its position is marked on Figure 2 (G). The elevation above mean tide level (29 ft.), and the overflow system, maintain the pool at a low salinity, ranging in our experience from 3·5 to 6·0‰ (sea-water 35‰). A dense population of protophyta maintains a high oxygen-content at most times. The phosphate and nitrate supply is good, on account of the presence of sea-birds nesting above the pool. At a time when protophyte production was extremely high (the water being a vivid green), the phosphate content was 90 mgm./cu.m., the nitrate low (c. 10 mgm./cu.m.); these figures are not representative, as much of the soluble nitrate and phosphate was obviously contained in the organic life present. The protophyta are chiefly Desmids, *Scenedesmus* being very abundant.

Triangle Pool supports a varied animal population, notably the larvae of Odonata, Chironomidae, and the mosquito *Aedes concolor*; adults and larvae of Corixids, Notonectids, Dytiscids and Gyrinids; and a surface population of water-skaters (Gerridae).

(*b*) *Freshwater Springs* (Pl. xix, E): These two pools are situated about 28 feet above mean tide level, behind and to the south of the beach, I (Fig. 2, B). They are man-made ponds dug in the *Stenotaphrum* community to a depth of about five feet, the water being retained by a clayey soil, probably the 'Y' horizon referred to earlier. Their salinity is low (within our experience, usually 0·45–0·70‰, rarely

as high as 1·08‰), due both to the shelter of this area from spray, and to continual drainage. The animal population appears to be restricted to larvae of Chironomidae and of *Aedes concolor*.

(*c*) *Phragmites Soak*: Water seeping through a sand-drift on the south side of I, and flowing at all times except in very dry seasons, accumulates in hollows in the dolerite about 25 feet above mean tide level. Almost continual flow keeps the salinity low (normally about 0·50‰ for the highest pool, and 0·95‰ for a pool some 5 feet lower down (Pl. xix, H)), in spite of low elevation. The upper pool (Pl. xix, G) occasionally dries up, passing through stages of high salinity. The population of these pools consists chiefly of larvae of *Aedes concolor*, with Corixids, Notonectids, and a few Amphipods.

(*d*) *Pools of High Salinity*: Many rock-pools above the reach of the tide, but filled frequently with spray and with a salinity approximating to that of sea water, form the habitat of larvae of *Aedes concolor*, but appear to be too saline for other insects. A pool on Periwinkle Pt., I (Pl. xix, F), although 40 feet above mean tide level, falls in this category, its salinity ranging from 18·9 to 50·8‰ in our experience; it seldom overflows, on account of the contour of the rock, and in effect acts as a concentrating-pan for the large amounts of spray which are driven across Periwinkle Pt. by southerly winds. In addition to the larvae of *Aedes concolor*, periwinkles (*Nodilittorina tuberculata*) inhabit this pool.

Pools of this fourth type are common about the 10–20 ft. contours on I and II, and on III occur up to about 45 feet. Some of the pools on the upper parts of III have a fairly low salinity (down to 4·25‰ on some occasions), and Corixids and Chironomid larvae occasionally occur in them; but the other types which are found in Triangle Pool, with a comparable salinity, are not present in the pools of III. On the platform and eastern slopes of IV, pools of the fourth category occur, some with salinity low enough to accommodate Corixids and Notonectids. On the higher parts of V, small rock-pools occur, with larvae of *Aedes concolor*, and species of Cladocera and Ostracoda. The only sample which we have been able to secure from V for salinity determination, from a pool on the top of the island, gave a value of 14·2‰, at a dry period when pools on the other islands were showing unusually high salinities.

(2) *Rock habitats*:

(*a*) *Lichens on rock surfaces*: In nearly all places above the 10-ft. contour where igneous rock is exposed, placoid lichens develop in abundance. The frequent occurrence of *Nodilittorina tuberculata* in this situation suggests that it may feed on lichens. The moth *Halone sinuata* Walk. occurs in this zone, its larvae apparently feeding on lichens.

(*b*) *Boulders*: Accumulations of rounded boulders immediately below the lower limit of vascular plants afford an animal habitat on the south-western part of I and the eastern slopes of IV. In the latter place, Machilids are particularly abundant, and lizards, spiders and ants sometimes occur. Few species occupy this habitat on I. Boulders in the more open parts of the *Scirpus nodosus* community in the 'blow-out' area of I offer shelter to large numbers of Dermaptera, and occasionally to other types.

(*c*) *Mosses and Liverworts*: On I, mosses and the liverwort *Marchantia* occur in moist situations on rocks or soil, and on the eastern slopes of IV mosses grow under similar conditions. The area of this habitat is very restricted, and it is doubtful whether it is occupied by any characteristic animal types.

(3) *Kelp*: This community, which has been mentioned earlier, scarcely constitutes a typically terrestrial habitat, falling rather in the littoral zone.

(4) *Bare sand*: Drifts of bare sand occur on the slopes on the north and south-east of I, and similar situations occur within vascular plant communities, as in the disturbed parts of the *Stenotaphrum* community. Bembecid wasps are the main frequenters of this barren habitat, and they derive their food from other areas.

Variety of Animal Types.

A diverse animal population is present on the Five Islands, including mammals (introduced rabbits), land birds (about a dozen species), reptiles (at least four species of lizards), land Mollusca (one species), insects (16 orders, with more than 50 families represented), numerous species of Arachnids, Myriapods (Chilopoda, Diplopoda), Crustacea (terrestrial Isopods and Amphipods; Cladocera and Ostracoda in pool habitats), and one terrestrial species of Oligochaeta. The animal populations will be dealt with specifically in subsequent papers.

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(In addition to works quoted in the text, the above list includes the sources of most of the taxonomic names used in the paper. The names used for birds are in all cases those given by Mathews, and authors of species have therefore been omitted.)

TABLE 1.

Explanation: For Life-Form symbols, see explanation to Table 4.
Introduced species marked with an asterisk.
Abbreviations: vr, very rare; r, rare; o, occasional; c, common; c1, common (locally dominant), c2, common (locally co-dominant); lc, locally common; o1, occasional (locally common); o2, occasional (locally co-dominant).

	I.	II.	III.	IV.	V.	Life-Form.	Remarks.
Dilleniaceae.							
Hibbertia volubilis Andr.	r	—	—	—	—	N'.	Among *Stenotaphrum* on north-west portion of **I**.
Menispermaceae.							
Stephania hernandifolia (W. et Arn.) Walp.	—	—	—	c	—	Ch.	Epharmonic variation with relatively small leaves, growing as a low straggling creeper on plateau, **IV**; formerly the commonest plant on central part of plateau, now partly displaced by *Mesembryanthemum aequilaterale*.
Cruciferae.							
Lepidium hyssopifolium Desv.	—	—	—	c	—	Th.	Moderately common on plateau, **IV**; has increased since 1936, when it was very rare.
Rutaceae.							
Correa alba Andr.	r	c1	o2	c2	—	N.	Dominant or co-dominant in nearly all areas carrying shrubs.
Oxalidaceae.							
Oxalis corniculata Linn. ..	r	r	—	r	—	H.	On bare sandy soil, or in grassland (**I, II**); in centre of plateau (**IV**).
Malvaceae.							
Malva parviflora Linn.*	—	—	—	—	vr	Th.	In shallow soil on higher parts of island.
Portulacaceae.							
Claytonia Pickeringi (A. Gray) F. v. M.	—	—	—	c	—	Ch.	In shallow moist saline soil in rock basins, eastern slopes of **IV**.
Portulaca oleracea Linn.	—	—	o	c	c	Th.	Similar situations to the preceding species, on **III, IV** and **V**.
Caryophyllaceae.							
Spergularia rubra (Linn.) J. et C. Presl.	—	—	vr	o	r	Ch.	As for *Portulaca*.
Chenopodiaceae.							
Atriplex cinereum Poir. ..	—	—	—	r	o	N'.	On **IV**, rare on slopes and plateau; on **V**, in shallow soil in rock crevices, etc.; appears to be increasing in numbers on **V** (July, 1938).
A. patulum Linn.* ..	vr	—	—	—	—	Th.	In *Stenotaphrum* community near beach, **I**; only seen on earlier visits (1934–5).
Enchylaena tomentosa R.Br.	r	r	o	c	—	Ch.	Usually on dry sandy soil, or in rock crevices with little soil.
Rhagodia baccata (Labill.) Moq.	—	vr	—	—	—	Ch.	In *Stenotaphrum* community.
R. hastata R.Br. ..	o	o	c	o	vr	Ch.	In *Stenotaphrum* community on **I** and **II**; in *Sporobolus* community on higher parts of **III**; on **IV**, both on plateau and eastern slopes.
R. nutans R.Br.	—	—	—	r	—	Ch.	In rocky situations.
Salicornia australis Banks et Sol.	—	—	c1	—	—	Ch.	In wet saline soil in cuppings of the underlying rock.
Salsola Kali Linn. ..	r	—	—	—	—	Th.	In dry sandy situations.
Aizoaceae.							
Mesembryanthemum aequilaterale Haw.	o	o	c	c	o	Ch.	Locally common on rocks, with little soil; also on those parts of the plateau, **IV**, lacking shrubs, where it has become dominant since March, 1936.

TABLE 1.—*Continued.*

	I.	II.	III.	IV.	V.	Life-Form.	Remarks.
M. australe Sol.	—	—	—	vr	—	Ch.	As for *Claytonia*.
Tetragonia expansa Murr.	lc	lc	o	o	o	Ch.	On **I** and **II** forms a distinct local facies of the *Stenotaphrum* community; elsewhere in shallow soil on rocks, or rarely on plateau of **IV**. Listed as an annual by Moore and Betche, but perennial in these localities according to our observations.
Polygonaceae.							
Rumex Brownii Campd. ..	vr	—	—	—	—	N'.	A few plants behind the beach in the *Stenotaphrum* community, **I**; observed only on recent visits (since August, 1937); possibly a recent migrant to the island, though indigenous in this part of New South Wales.
R. crispus Linn.*	—	—	—	vr	—	Th.	On eastern slopes, **IV**; first observed in March, 1938, and probably a recent migrant. Apparently therophytic in this locality.
Phytolaccaceae.							
Phytolacca octandra Linn.*	c	o	—	vr	—	Th.	Usually on sandy soil; forms a distinct local (seasonal) facies of the *Stenotaphrum* community on **I**.
Leguminosae.							
Desmodium varians (Labill.) Endl.	—	—	—	vr	—	Ch.	Eastern slopes of **IV**.
Glycine clandestina Wendl.	—	—	—	r	—	Ch.	On plateau. **IV**.
Kennedya rubicunda Vent.	r	o	vr	o	—	N'.	Climbing over other plants, e.g. *Stenotaphrum* on **I** and **II**, and *Westringia* on plateau of **IV**. Classed as a nanophanerophyte, but more of a chamaephyte on **I** and **II** on considerations of height.
Crassulaceae.							
Tillaea Sieberiana Schultes	r	r	—	o	—	Ch.	In dry rocky situations.
Umbelliferae.							
Apium prostratum Labill.	o	o	o	—	—	Ch.	In moist soil amongst rocks, usually at a low elevation.
Cactaceae.							
Opuntia inermis P.DC.*	c	c	c	c	—	S.	On dry soil or almost bare rocks, often becoming dominant, or co-dominant with *Stenotaphrum*, etc., but subjected from time to time to attempts at eradication.
Compositae.							
Centipeda minima (Linn.) A.Br. et Aschers	—	—	—	o	—	Th.	On plateau, **IV**.
Cirsium lanceolatum (Linn.) Scop.*	r	r	—	—	—	Th.	In more open parts of *Stenotaphrum* community.
Cotula australis (Less.) Hook f.	—	o	—	vr	—	Th.	In *Sporobolus* community, **II**; on eastern slopes, **IV**.
C. coronopifolia Linn. ..	—	—	—	o	—	Ch.	As for *Claytonia*.
Erechthites arguta (A. Rich.) DC.	—	—	—	o	—	Th.	On plateau, **IV**.
Gnaphalium luteo-album Linn.	r	r	—	—	—	Th.	In *Stenotaphrum* and *Sporobolus* communities.
Hypochoeris glabra Linn.*	—	—	—	r	—	Th.	On plateau. Only seen on recent visits (March, 1938), probably a recent migrant.
Inula graveolens (Linn.) Desf.*	o	—	—	—	—	Th.	On bare soil, as in the more open parts of the *Scirpus nodosus* community; very rare on our earlier visits, has increased markedly in numbers (1938).
Onopordon Acanthium Linn.*	r	r	—	—	—	Th.	In more open parts of *Stenotaphrum* community.

TABLE 1.—*Continued.*

	I.	II.	III.	IV.	V.	Life-Form.	Remarks.
Senecio lautus Sol. ..	r	r	c	o	—	Ch.	In *Stenotaphrum* community on **I** and **II**; in *Sporobolus* community on **III**; on plateau, **IV**.
S. mikanioides Otto.* ..	o	o1	—	o	—	Th.	On **I** and **II**, scrambling over *Stenotaphrum* and dead remains of *Opuntia*; on plateau, **IV**.
Sonchus asper Hill* ..	r	r	—	—	—	Th.	On bare soil.
S. maritimus Linn.* ..	r	r	—	r	—	Th.	As *S. asper*.
S. oleraceus Linn.* ..	r	r	r	o	r	Th.	As *S. asper*, sometimes on almost bare rocks; also in more open parts of *Stenotaphrum* community on **I** and **II**.
Taraxacum officinale Weber*	—	—	vr	r	—	Th.	As *Sonchus asper*.
Campanulaceae.							
Lobelia anceps Thunb. ..	o	o	—	c	—	Ch.	In same situations as *Apium*, occasionally in drier situations.
Wahlenbergia gracilis (Forst. f.) A.DC.	vr	vr	—	—	—	Th.	In grassland.
Goodeniaceae.							
Scaevola calendulacea (Andr.) Druce.	vr	—	—	—	—	Ch.	In *Stenotaphrum* community, north-west portion of **I**.
Gentianaceae.							
Erythraea australis R.Br...	r	r	—	—	—	Th.	In grassland.
Plantaginaceae.							
Plantago varia R.Br. ..	r	—	—	c	—	Ch.	Usually in shallow soil in rock crevices.
Primulaceae.							
Anagallis arvensis Linn.*	r	r	—	—	—	Th.	In more open parts of *Stenotaphrum* community.
Samolus repens (Forst.) Pers.	o	o	vr	r	—	Ch.	In similar situations to *Apium*.
Asclepiadaceae.							
Marsdenia rostrata R.Br.	r	—	—	—	—	N′.	Scrambling over *Stenotaphrum*, north-west corner of **I**.
Convolvulaceae.							
Dichondra repens Forst. et f.	r	r	o	c	—	H.	On **I**, **II** and **III**, in dry sandy soil or more open parts of grass communities; on **IV**, on plateau and ledges of westerly rock face.
Solanaceae.							
Datura Stramonium Linn.*	vr	—	—	—	—	Th.	A few plants near the beach, **I**. First observed in 1938, and probably a very recent migrant.
Lycium ferocissimum Miers*	—	—	—	—	vr	Th.	In shallow soil between rocks; apparently therophytic in this locality.
Solanum nigrum Linn. ..	vr	vr	—	vr	vr	Th.	In grassland (**I**, **II**); on plateau (**IV**); in shallow soil on top of **V**. Doubtfully native.
Labiatae.							
Plectranthus parviflorus Henck.	r	r	—	c	—	N′.	Usually in dry shallow soil in rock crevices; also in *Stenotaphrum* community (**I**, **II**), and on plateau (**IV**). Barely falls within the nanophanerophyte class.
Westringia rosmariniformis Sm.	r	o2	—	c2	—	N.	Co-dominant with *Correa* in shrub communities of **IV** and parts of **II**; on **IV** attains local dominance in some places. A few bushes on the north side of **I**.
Myoporaceae.							
Myoporum ellipticum R.Br.	—	—	o2	c	—	N.	Forms a local facies of the shrub community on **IV**; co-dominant on **III** where shrubs are developed.
Liliaceae.							
Lomandra longifolia Labill.	c	vr	—	—	—	H.	As tussocks holding the sandy soil at the former level on **I**; on **II**, rare in the *Stenotaphrum* community.

TABLE 1.—*Continued.*

	I.	II.	III.	IV.	V.	Life-Form.	Remarks.
Commelinaceae.							
Commelina cyanea R.Br.	c	o	r	c	c	Ch.	On **I**, **II** and **III**, in grass communities; on **IV**, on plateau and ledges of westerly rock face; in shallow soil in rock crevices on **V**.
Centrolepidaceae.							
Centrolepis fascicularis Labill.	—	o	—	—	—	Th.	In *Sporobolus* community, locally fairly common.
Cyperaceae.							
Cyperus (*Pycreus*) *polystachyus* (Rottb.)	o	o	—	—	—	H.	In dry shallow soil.
Scirpus cernuus Vahl. ..	o	o	—	vr	—	Ch.	In similar situations to *Lobelia*, *Samolus* and *Apium*.
S. nodosus Rottb... ..	cl	o	r	o	—	H.	In shallow accumulations of sand, or on almost bare rock; also in central part of plateau, **IV**.
Gramineae.							
Agrostis avenacea Gmel. (=*Calamagrostis filiformis* (Forst.) Pilger).	r	—	r	o	—	Th.	Among *Stenotaphrum* or *Sporobolus* (**I**, **III**); in shallow soil amongst rocks, eastern slopes of **IV**.
Calamagrostis quadriseta (Labill.) Spreng.	vr	r	—	—	—	H.	In *Stenotaphrum* community.
Cynodon dactylon Rich. ..	r	r	—	—	—	H.	In *Stenotaphrum* community.
Digitaria marginata Link.	vr	—	—	c	c	Th.	In *Stenotaphrum* community (**I**); in shallow soil amongst rocks (**IV**, **V**).
Eleusine indica Gaertn. ..	—	—	—	—	vr	Ch.	In shallow soil on higher parts of island.
Echinochloa crus-galli (Linn.) Beauv.	—	—	—	—	vr	Th.	In similar situations to the preceding species. Possibly introduced, but allowed as indigenous by Moore and Betche.
Entolasia marginata (R.Br.) Hughes.	—	—	—	r	—	H.	On ledges of western rock face, **IV**.
Imperata cylindrica (Linn.) Beauv. var. *Koenigii* D. and S.	o	r	—	—	—	H.	In *Stenotaphrum* community.
Paspalum distichum Linn.	—	—	—	vr	r	H.	In shallow soil in rock crevices.
Phragmites communis Trin.	lc	—	—	—	—	H.	In *Stenotaphrum* community at low elevations, south side of **I**.
Setaria glauca (Linn.) Beauv.	o	vr	—	—	—	Th.	In *Stenotaphrum* and *Sporobolus* communities.
Sporobolus virginicus (Linn.) Kunth.	o	cl	cl	—	—	H.	Dominant over most of the western part of **III**, and on the eastern part of **II** wherever shrubs are not developed. On **I**, dominant only on Periwinkle Pt., apparently having been displaced elsewhere on **I**, and on the western end of **II**, by *Stenotaphrum*. On dry sandy soil, and on ill-drained soil amongst rocks.
Stenotaphrum secundatum (Walt.) Kuntze*	cl	cl	—	o	o	Ch.	Dominant over much of **I** and **II**, on sand. On **V**, in soil in rock crevices. Since 1934, has colonized **IV**, being now well established on eastern slopes and plateau. Grows as a chamaephyte in these localities, though hemicryptophytic in some localities.
Themeda australis (R.Br.) Stapf.	—	o	—	—	—	H.	In dry shallow soil on rocks, and in *Stenotaphrum* and *Sporobolus* communities.
Zoisia macrantha Desv. ..	r	o	r	—	—	H.	With *Sporobolus*.
Polypodiaceae.							
Pteridium aquilinum (Linn.) Kuhn.	o	o	—	—	—	G.	In *Stenotaphrum* community.

TABLE 2.

Properties of surface soils (0–2 inches) from various communities.

Community and Location.	Height above Mean Tide Level.	pH.	Loss on ignition (%).	W.R.C. (%).	Chloride (%).
	Feet.				
Correa-Westringia community :					
Correa, Centre of **II** : Soil 1 ft. deep, derived from dune sand contaminated with doleritic soil. Well drained*	45	6·0–6·1	11·2	58	0·026
Correa-Westringia, Centre of **II**, south side. Depth, origin and drainage as last	35	5·9–6·0	16·5–17·9	63	0·101–0·112
Correa-Westringia, **IV**, plateau, north end: Soil 1 ft. deep, well drained, derived from trachy-andesite	40	5·2–5·3	45·0–50·2	125	0·034
Stenotaphrum community :					
High Hummock, **I** : Dune sand, 8 ft. deep, very well drained	70	5·3–5·4	1·6–4·5	28–37	0·013
II, west end : Soil 2 ft. 6 in. deep, derived from dune sand, well drained	40	5·3–5·4	10·8	43	0·052
I, between beach and Camp Hummocks : Deep dune sand, well drained. (*Tetragonia* on sample with 11% humus)	25	5·9	8·0–11·0	38–54	0·023
I, Camp Hummocks : Deep dune sand, well drained. With *Lomandra longifolia*	50	5·8	1·2	28	0·014–0·015
Sporobolus community :					
I, Periwinkle Pt. : Soil 8–15 inches deep, derived chiefly from dune sand, with slight contamination from dolerite ; not very well drained	40	6·1–6·2	13·3	51–56	0·032
II, centre, south side : Soil 1 ft. deep, fairly well drained, derived from dune sand contaminated with doleritic soil	35	6·6–6·7	12·5	70	0·064
II, south-east corner : Soil 1 ft. deep, derived chiefly from underlying dolerite ; poorly drained because of cupping of underlying rock*	35	6·5	15·0	104	0·056
III, top of island, west end : Soil about 1 ft. deep, well drained, derived from dolerite, possibly with slight admixture of wind-borne sand	50	5·5	25·6	86–102	0·093
III, near ecotone with *Salicornia* community : Soil 6 in. deep, derived from dolerite, poorly drained	35	7·2–7·4	18·1–21·1	112	0·443–0·653
Scirpus nodosus community :					
I, 'blow-out' area : Recent sandstone, with 1–2 inches of wind-blown sand collected around *Scirpus* tussocks ; very dry and well drained	50	5·4	3·0	29	0·036
II, 'blow-out' area, near east end : Soil similar to last, but resting on dolerite, not sandstone	45	6·2	3·4	33	0·032–0·033
Mesembryanthemum community :					
IV, Centre of plateau : Soil 2 ft. deep, well drained, podsolized, derived from trachy-andesite	40	5·4–5·5	26·5	101	0·092
IV, edge of plateau : Soil 1–2 inches deep, restricted to vicinity of plant, rock elsewhere bare ; soil well drained, derived from trachy-andesite	35	6·0–6·1	44·9	162	0·203

* Water content (20/8/37) 14% and 84%, respectively, of the dry weight.

TABLE 2.

Properties of surface soils (0–2 inches) from various communities.

Community and Location.	Height above Mean Tide Level.	pH.	Loss on ignition (%).	W.R.C. (%).	Chloride (%).
	Feet.				
Salicornia community:					
III: Soil 3 inches deep, derived from dolerite, very badly drained	30	7·4–7·5	11·4	97	0·848
III: Soil 6 inches deep, as above, but with slightly better drainage; near ecotone with *Sporobolus* community	35	6·9–7·0	30·4	148	0·460
Spergularia-Claytonia-Portulaca community:					
IV, eastern slopes: Soil 1–3 inches deep, derived from trachy-andesite; poorly drained, in rock basin	25	5·7–5·8	29·4–32·3	116	0·117
Scirpus cernuus community:					
I, below High Hummock: Dune sand 3 inches deep, lodged in rock crevices; poorly drained	25	6·8	8·2	48	0·062
I, below *Phragmites* Soak: Soil 1 inch deep, dune sand accumulated in shallow rock-pool, filled from slowly-running soak; salinity of pool when soil collected, Cl 0·76‰	20	6·6–6·7	3·5	33	0·029
Lomandra community:					
See Sample 4 of *Stenotaphrum community.*					

The pH values were measured by the quinhydrone method (gold electrode) as soon as practicable after collection of the sample, usually within three days. Little drift was observed in the pH when the soils were stood with water for varying times, very probably because of natural buffering.

For the other estimations all soils were previously passed through a 1 mm. sieve. The percentage loss on ignition of oven-dry soil gives a fairly reliable measure of the organic matter (humified and unhumified), little clay and practically no calcium carbonate being present. Water-retaining capacity was calculated by weighing saturated soils, contained in squat metal cylinders with gauze bottoms lined with filter-paper, and weighing again after drying in an oven at 90°–100° C. The W.R.C. is expressed as a percentage of the dry soil, allowance being made for the water held by the apparatus at the first weighing. The figures are comparable *inter se*, but higher than would be obtained by most methods. The chloride content (expressed as percentage Cl-ion per unit dry weight of soil) was obtained by lixiviating known weights of oven-dry soil with hot distilled water, and estimating the filtrate with standard silver nitrate. The salinity of the soil solution, involving water-content of the soil, was judged too variable from season to season to merit calculation.

The pH values are controlled by (1) the origin of the soil, dune sand being lowest, soil derived from trachy-andesite intermediate, that derived from dolerite highest; (2) salinity, as given by chloride content, high salinity raising the pH; and (3) humus-content, high humus-content lowering the pH. The humus-content is largely controlled by drainage, poorly-drained soils having high humus-content; soils from shrub communities are also rich in organic matter generally on account of accumulations of dead leaves. *Mesembryanthemum* as a stage in a lithosere also has a soil of high organic content. The W.R.C. is controlled by texture (low for dune sand, high for soils from igneous rocks), and by organic content. The chloride content is governed both by incidence of salt spray (depending on aspect, height and distance from shore), and by leaching, poorly-drained soils tending to have a high salinity.

TABLE 3.

Soil Sample.	Nitrate (mgm. N_2O_5 per gm.).	Phosphate (P_2O_5, parts per million).	NH_3.
Stenotaphrum community, penguin rookery between beach and Camp Hummocks, I ..	0·086	3·03–4·72	+
Stenotaphrum community, High Hummock, I: No birds nesting near this situation ..	0·004	5·76	—
Dune community, mainland at Red Point: No birds present	0·010	3·54	—

Phosphate, nitrate and ammonia content for soil from a penguin rookery, and from similar plant communities where no birds are normally present. Nitrate and phosphate estimated colorimetrically, the former in filtrates from known weights of dry soil within 24 hours of collecting, the latter from known weights of dry soil, calcined and lixiviated. Ammonia was estimated qualitatively with Nessler's Reagent, in filtrates from aliquot parts of soil; + represents a deep colour, — no colour.

TABLE 4.

Life-Form Spectra.

	S.	E.	MM.	M.	N.	N′.	Ch.	H.	G.	HH.	Th.	Number of Species.
Five Islands, I-V—												
(A)	—	—	—	—	5	10	38	22	2	—	23	63
(B)	1	—	—	—	4	7	31	17	1	—	39	81
Five Islands, I, II—												
(A)	—	—	—	—	5	11	32	27	2	—	23	44
(B)	2	—	—	—	4	9	26	21	2	—	36	57
Five Islands, III—												
(A)	—	—	—	—	11	5	52	21	—	—	11	19
(B)	5	—	—	—	9	5	45	18	—	—	18	22
Five Islands, IV—												
(A)	—	—	—	—	8	8	50	13	—	—	21	38
(B)	2	—	—	—	6	6	43	11	—	—	32	47
Five Islands, V—												
(A)	—	—	—	—	0	8·5	50	8·5	—	—	33	12
(B)	—	—	—	—	0	6	44	6	—	—	44	16
Brush Island—												
(A)	—	1·5	—	11	8	13	30	28	1·5	—	7	61
(B)	—	1·5	—	10	8	12	27	26	1·5	—	14	66
Eucalyptus pilularis Association in Bulli District. (B)	—	2	10	7	15	12	12	24	9	—	9	82
'Normal' Spectrum ..	1	3	6	17	20		9	27	3	1	13	400

(A), indigenous species; (B), total species.

S, stem-succulent; E, epiphyte; MM, mega- and meso-phanerophytes; M, microphanerophyte; N, woody nanophanerophyte; N′, other nanophanerophytes (perennial herbs or climbers with growing apex reaching more than 1 foot in height); Ch, chamaephyte; H, hemicryptophyte; G, geophyte; HH, halo- and hydro-phytes; Th, therophyte.

TABLE 5.
Introduced Plants.

	Number of Introduced Species.	Percentage of Species Introduced.	Life-Forms of Species Introduced.	Means of Entry of Species Introduced.
Five Islands. I-V ..	18	22	S 1, Ch 1, Th 16	W 9, F 2, FF 1, X 6
Five Islands, I, II ..	13	23	S 1, Ch 1, Th 11	W 7, F 1, FF 1, X 4
Five Islands. III ..	3	14	S 1, Th 2	W 2, FF 1
Five Islands. IV	9	19	S 1, Ch 1, Th 7	W 5, F 1, FF 1, X 2
Five Islands, V ..	4	2·5	Ch 1, Th 3	W 1, F 1, X 2
Brush Island	5	8	Th 5	W 3, F 1, X 1

For Life-Form abbreviations, see explanation to Table 4.

Means of entry: W, plumed fruit, wind-borne; F, fleshy fruit; FF, fleshy fruit and floating cladode; X, other means.

EXPLANATION OF PLATES XV-XIX.

Plate xv.

Vertical aerial photographs of the Five slands, scale 10 inches to the mile. A, Islands **I, II** and **III**; B, Island **IV**; C, Island **V**. For orientations see Plate xv*a*; for relative positions see Text-figure 1. Sun in approximately north-eastern position; half-tide. July, 1937. Photographs by Adastra Airways Pty., Ltd.

Plate xv*a*.

Outlines of principal communities of vascular plants. For all the islands, bare igneous rock is represented as black. In the transparency to Pl. xv, C (Island **V**), the white areas represent all areas occupied by vascular plants, which are very restricted and scarcely form definite communities. For the other islands, the following symbols are used for the various communities:

Plain white, *Stenotaphrum* community (*Phytolacca* facies with small crosses, *Tetragonia* facies with small black triangles); small circles, *Correa-Westringia* community; tussock symbols, *Scirpus nodosus* community; stippling, *Sporobolus* community; broken diagonal lines, *Mesembryanthemum* community; vertical shading, *Salicornia* community; heavy asterisks, *Lomandra* community; horizontal shading, *Spergularia-Claytonia-Portulaca* community; cross-hatching, loose sand.

Plate xvi.

Vertical aerial photograph of the Five Islands (**I, II** and **III**), Midway Reef, and the adjacent coast. Scale 4 inches to the mile. Sun in approximately north-western position; half-tide. August, 1937. Photograph by Adastra Airways Pty., Ltd.

Plate xvii.

A.—Camp Hummocks, **I**: Dune sand held at old level by *Stenotaphrum secundatum* (left) and *Lomandra longifolia* (right); sand elsewhere removed by wind action ('blow-out') to level of underlying recent sandstone. *Scirpus nodosus* tussocks growing in shallow sand accumulations at new level.

B.—Tussocks of *Lomandra longifolia* holding dune sand at old level, north-eastern part of **I**. *Scirpus nodosus* tussocks growing in very shallow soil collected around their bases; 'blow-out' area otherwise devoid of soil.

C.—North-eastern side of **I**, from the west end of **II**, showing drifts of sand removed from the top of **I** by wind action. The area so denuded is visible immediately above the large sand-drift, and to the right of the denuded area Camp Hummocks are seen on the upper parts of the island, where the vegetation has held the sand against erosion.

D.—'Blow-out' area, centre of **I**. Removal of the dune cover has exposed recent sandstone, which has weathered to an irregular surface by water action. Soil absent except for shallow accumulations of sand around tussocks of *Scirpus nodosus*; old shells (*Turbo*

stramineus Gmel., *Cymatium spengleri* Perry) from an aboriginal kitchen-midden have been left behind when the sand around and below them was blown off.

E.—Erosion of recent sandstone exposed by removal of sand cover, west of Periwinkle Point, **I**. *Scirpus nodosus* tussocks growing as in A, B and D.

F.—Portion of area shown in figure E, where water action has cut through the recent sandstone, exposing a clay soil. This clay is probably the illuvial horizon of a doleritic soil pre-dating cover of the area by dunes. *Mesembryanthemum aequilaterale* growing on left side of cutting.

G.—Bushes of *Correa alba* and *Westringia rosmariniformis*, with *Sporobolus virginicus* in foreground. East end of **II**.

H.—Bushes of *Westringia rosmariniformis*, south end of plateau, **IV**.

I.—Plateau of **IV**, looking north from near southern end. *Mesembryanthemum* community and bushes of *Correa* and *Westringia* in the background, and *Myoporum ellipticum* facies of shrub community on left.

J.—The beach, **I**: *Stenotaphrum secundatum*, with lower limit only 8 feet above mean tide level. Exposed sand with vegetation disturbed by burrows of sea-birds visible in central background. The boat is 16 feet long.

Plate xviii.

A.—Between the beach and Camp Hummocks, **I**: Permanent quadrat in portion of *Stenotaphrum* community disturbed by burrowing activities of sea-birds; looking north-east. Corners of quadrat (side 10 ft.) indicated by black rings. Bushes of *Phytolacca octandra* to the left. Date 18/12/37.

B.—Quadrat of figure A, 24/4/38. Bushes of annual *Phytolacca octandra* dead; about two inches of the surface sand removed by wind action, the isolated patch of *Stenotaphrum* near the centre of the quadrat partly undermined thereby.

C.—North side of **II**, near west end: Large expanse of *Opuntia inermis* killed by poisoning, March, 1936.

D.—*Opuntia* regenerating: Same locality as figure C, August, 1937.

E.—*Opuntia* regenerating: Living cladodes and dead remains, west edge of plateau, **IV**.

F.—*Sporobolus* community, near east end of **II**; on the left, the soil has been blown off, exposing the underlying dolerite. The stick is 1 metre high.

G.—Dense growth of *Scirpus nodosus*, 'blow-out' area near High Hummock, **I**.

H.—*Mesembryanthemum* community, surrounded by *Sporobolus* community, on the higher parts of the west end of **III**. The note-book is 8 inches high.

I.—Central part of plateau, **IV**, March, 1936: *Stephania hernandifolia* with *Plectranthus parviflorus* and species of Compositae. *Correa* and *Westringia* bushes in background.

J.—The same, March, 1938: *Mesembryanthemum aequilaterale* has largely displaced *Stephania*, etc.

Plate xix.

A.—*Salicornia* community, in depression on south side of **III**, near west end. *Sporobolus* and *Mesembryanthemum* communities in background. The note-book is 8 inches high.

B.—*Portulaca oleracea* growing in moist shallow soil in rock-basins, eastern slopes of **IV**.

C.—Gulls (*Bruchigavia novae-hollandiae*) nesting on the western end of **III**; vegetation *Sporobolus virginicus* with *Opuntia*.

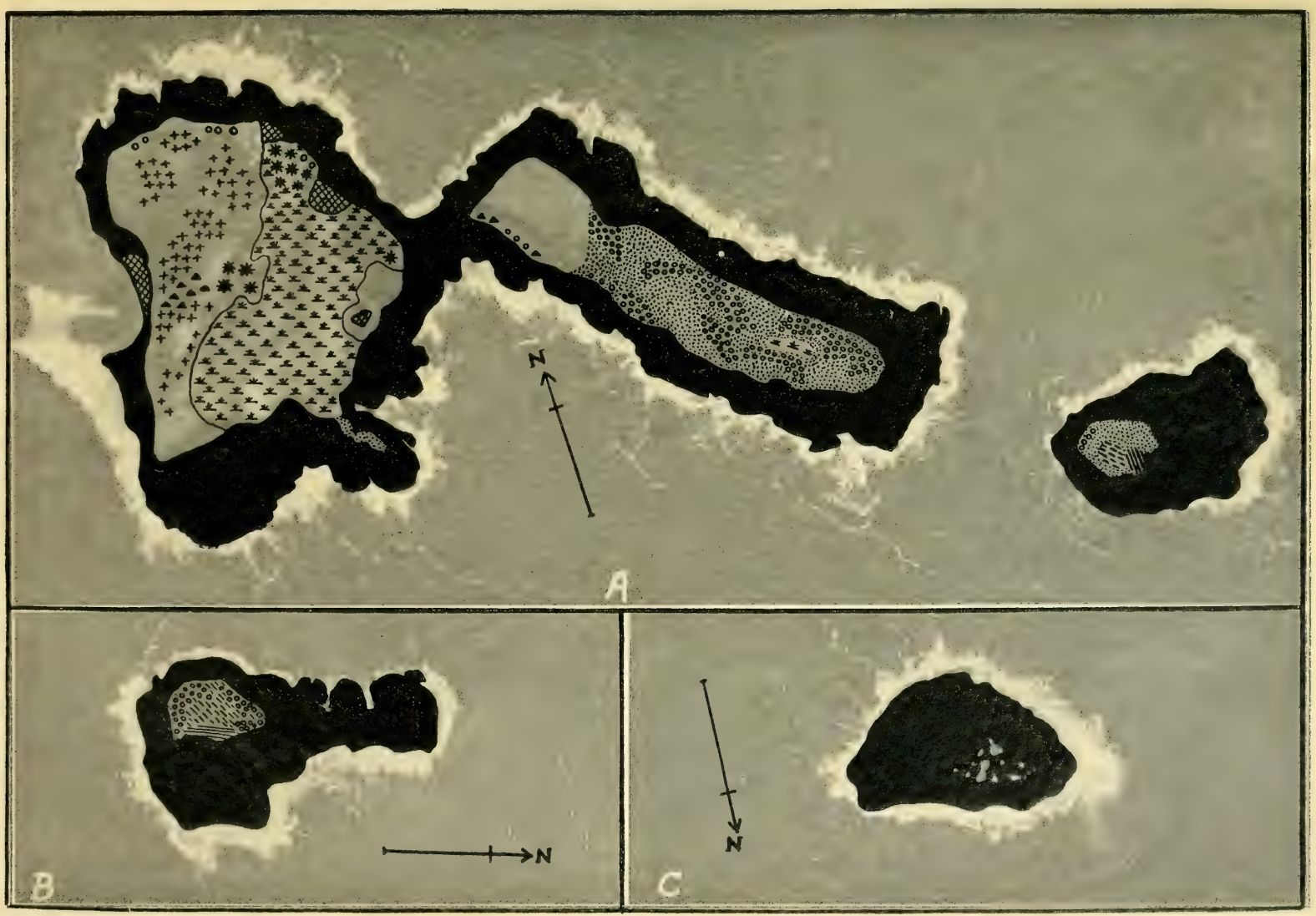
D.—Triangle Pool, **II**: A brackish pool 29 ft. above mean tide level.

E.—Freshwater Springs: Holes dug in the soil of the *Stenotaphrum* community, behind and to the south of the beach, **I**; about 28 ft. above mean tide level, with almost fresh water.

F.—Pool in hollow in the dolerite, Periwinkle Point, **I**. Elevation 40 ft. above mean tide level, but with high salinity, due to infrequent overflow and heavy incidence of spray. Periwinkles (*Nodilittorina tuberculata*) occur in and around this pool.

G.—Phragmites Soak, **I**: A pool at the bottom of the sand-drift, through which water percolates. Although less than 25 ft. above mean tide level, constant run-off ensures low salinity of the water. The vegetation of the sand-drift is *Stenotaphrum secundatum* (with stolons hanging down over the rocks), and *Phragmites communis*. The note-book is 8 inches high.

H.—A pool below that shown in the preceding figure, with slightly higher salinity. *Scirpus cernuus* (in rectangle) growing in wet sand in pool, *S. nodosus* in drier situation above. The characteristic crevices in the dolerite are apparent in this photograph.



Aerial photographs of the Five Islands.

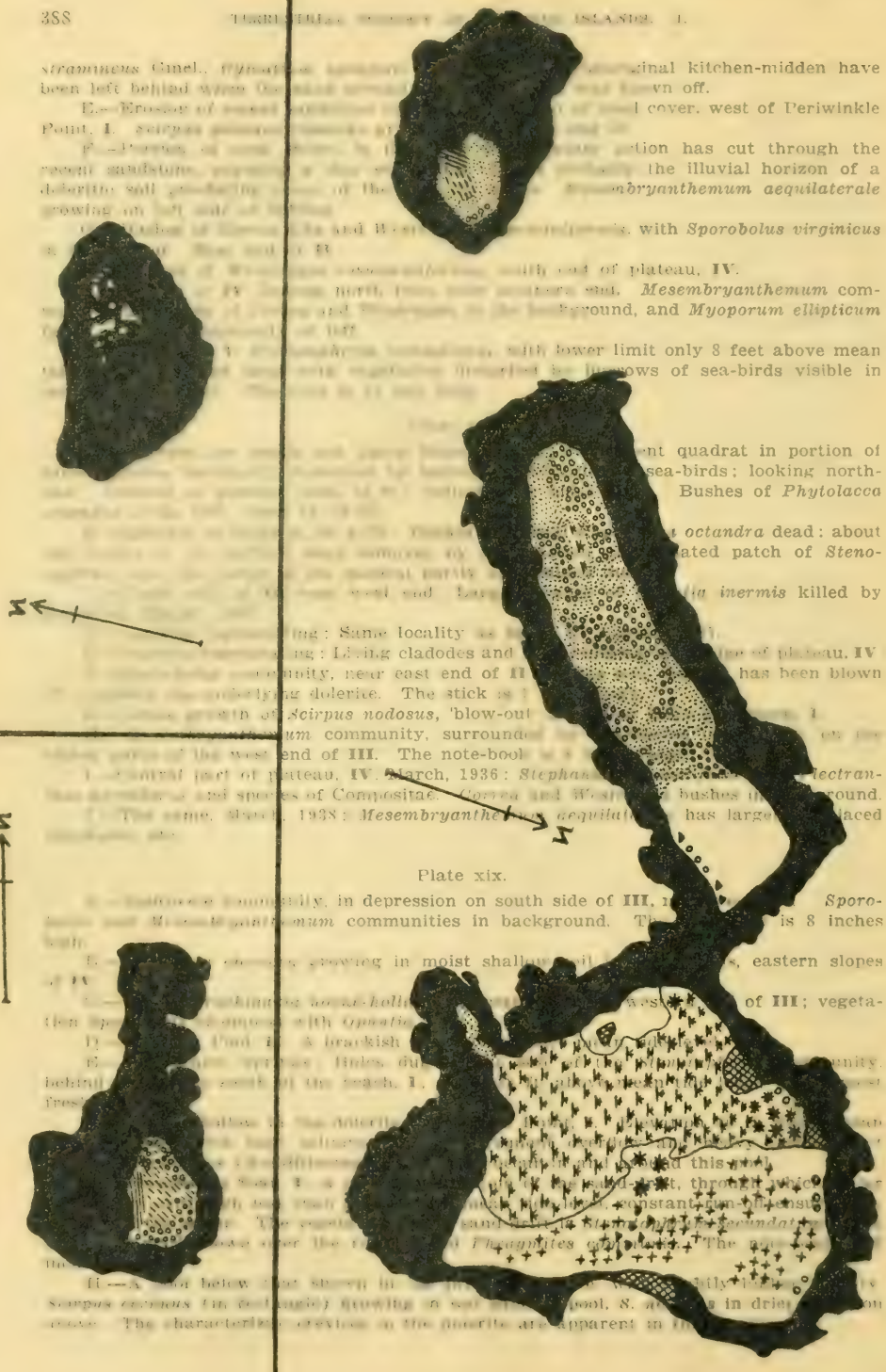
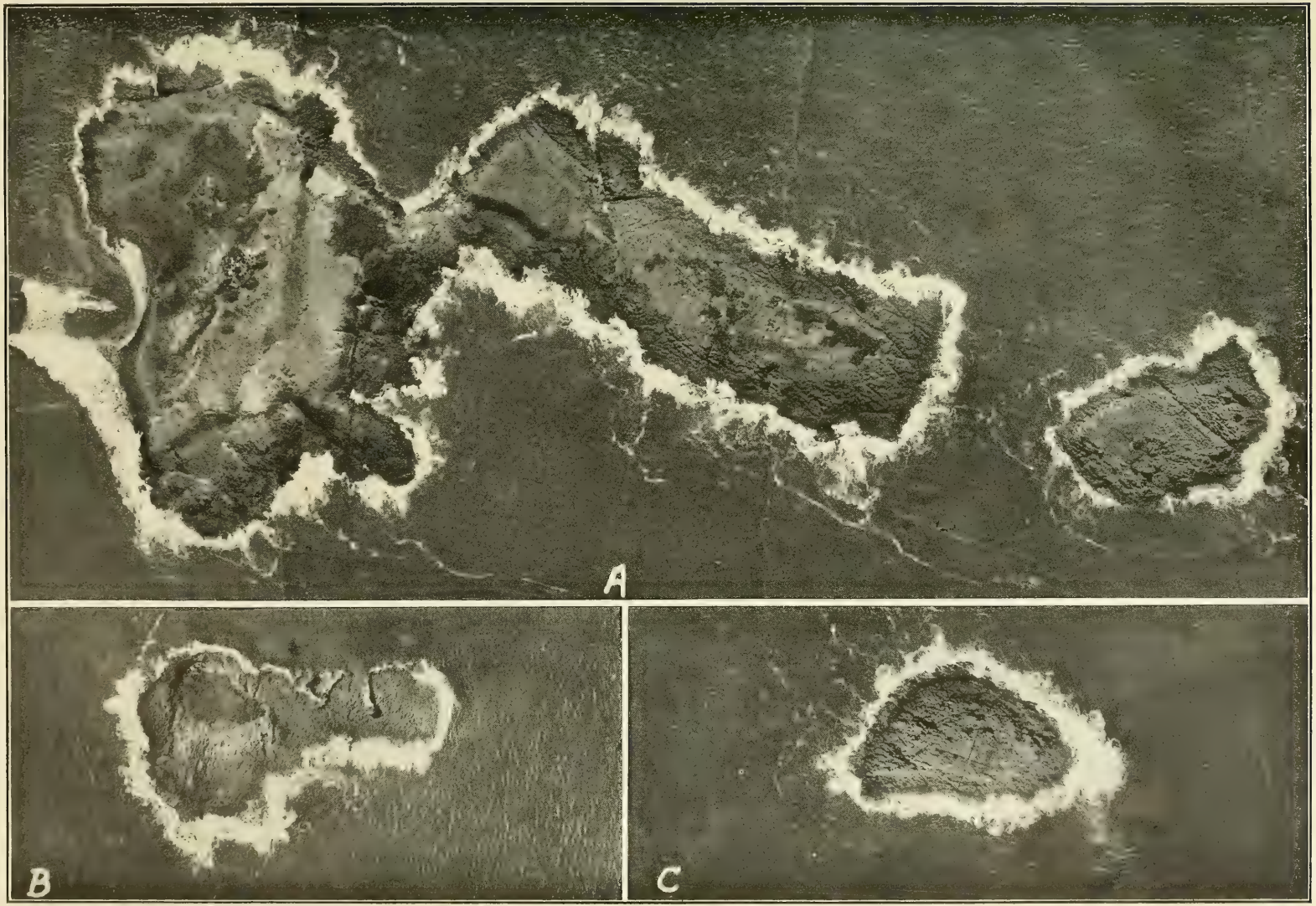
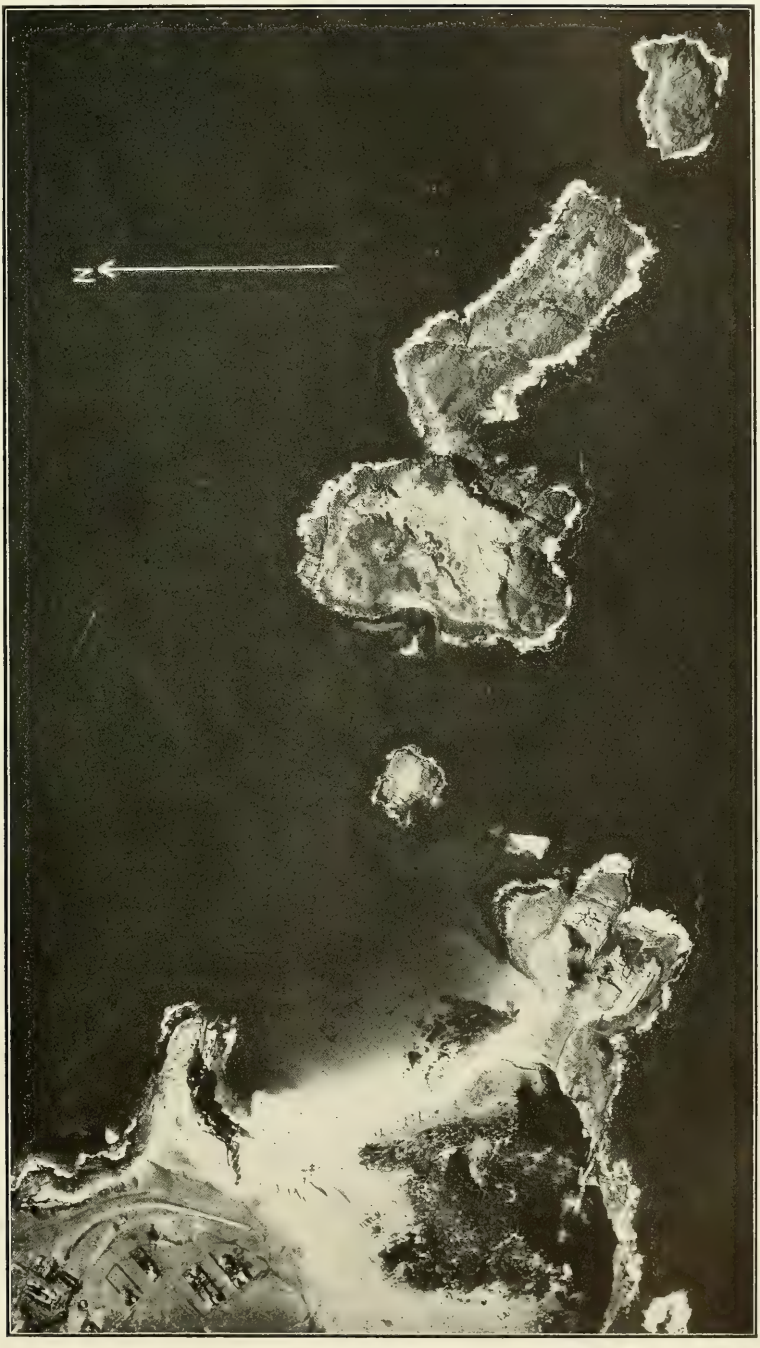


Plate xix.



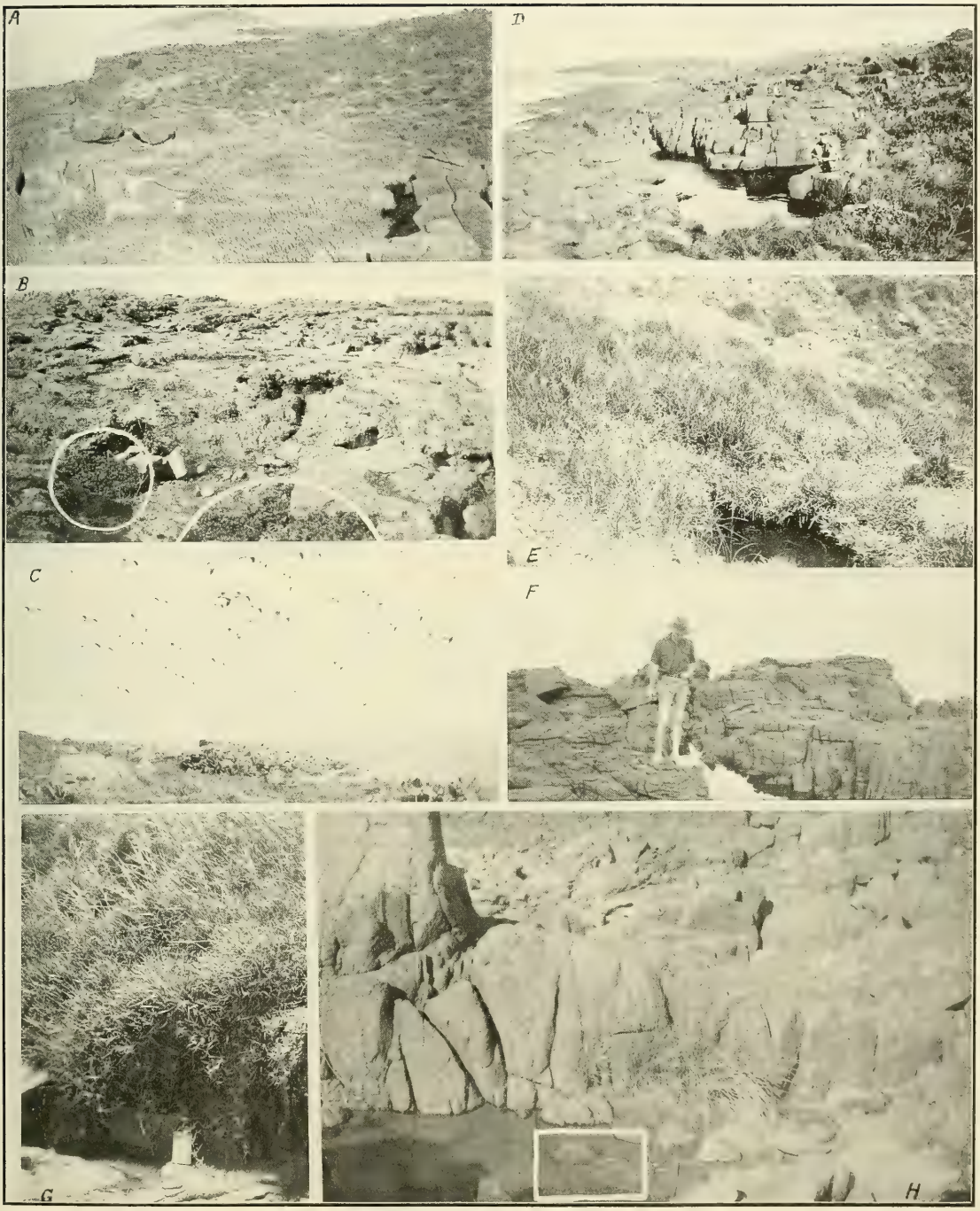
Aerial photographs of the Five Islands.



Aerial photograph of three of the Five Islands,
Midway Reef, and the adjacent coast.

Ecology of the Five Islands.

Ecology of the Five Islands.



Ecology of the Five Islands.

TEPPERELLA TRILINEATA CAM., A WASP CAUSING GALLING OF THE FLOWER BUDS OF *ACACIA DECURRENS*.

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(Plate xx; 9 Text-figures.)

[Read 26th October, 1938.]

Introduction.

Actually the observations in this thesis terminated on 7th May, 1937, but the writer continued the study until the adult wasps emerged in September, 1937, and the additional data are included here.

The galls under discussion were first noticed by the writer at Lindfield, Sydney, in August, 1933, on *Acacia decurrens* var. *pauciglandulosa* (Plate xx, figs. 4 and 5). The tree on which the galls were present was very old and the trunk and limbs were heavily infested with both coleopterous and lepidopterous borers which, even at that time, had caused the death of a number of limbs, while the tree, as a whole, was in an unthrifty condition. In January, 1938, the tree died.

General observations on the development of the galls, and the emergence of adult insects, were made during 1934, and it was found that a number of species of wasps emerged, that the life cycle was, at least in the predominant species, annual, and that emergence of the insects commenced in the spring.

In the spring of 1935, prior to the emergence of any adults, a large number of galls were collected and retained in glass jars, and it was found that a remarkable number of species of insects emerged from the galls, but three chalcid wasp species far outnumbered all others. These three species were *Tepperella trilineata* Cam., *Megastigmus* sp., and *Eurytoma* sp., the latter species outnumbering the other two combined.

The species of *Megastigmus* and *Eurytoma* just mentioned were submitted to Dr. A. B. Gahan, Senior Entomologist of the United States Department of Agriculture, who stated that they were dissimilar to any species in these genera in the collections of the United States National Museum, and he expressed the opinion that they were probably new.

The writer has since compared both species with all available descriptions of species in these two genera described from Australia and has concluded that both species are new. These two species will be described in detail in papers concerning their morphology and biology which are shortly to be published.

Early in 1936 a complete study of the three predominant species was commenced and was continued until the emergence of the adults in the spring and summer of 1937. Large numbers of galls were collected in the spring of 1936 and a detailed record was kept of all species emerging.

* This is one of ten papers on Australian Chalcidoidea submitted to the University of Sydney in fulfilment of the requirements for the degree of Doctor of Science in Agriculture.

Of a total of 3,511 adult wasps which emerged, 3,327 comprised the three predominant species previously mentioned; 101 were *Coelocyba nigrocincta*, another chalcid species, while the remaining 83 individuals comprised a further eight wasp species, making a total of twelve hymenopterous species bred from the galls.

Of these twelve species, ten were Chalcids, one was a Braconid, and one was a Bethylid. There is little doubt that the Braconids and Bethylids, which were few in number, were primary parasites of a species of lepidopterous larva, which was at times found feeding in the galls.

As a result of the investigations of the writer the detailed life-histories of the three predominant chalcid species have been elucidated, and at the same time some information concerning the other species of gall inhabitants has been obtained.

Acacia decurrens, which is a bipinnate species of wattle, occurs in New South Wales, and also in Queensland, Victoria, and Tasmania, being predominantly a coastal species, but extending also to the Tablelands. Buds appear several months before flowering and specimens in the collections at the Sydney Botanic Gardens obtained from many localities in New South Wales were in flower in December.

A. decurrens var. *pauciglandulosa* grows very abundantly in the coastal districts in the vicinity of Sydney, and this variety is particularly common in the northern suburbs of Sydney. Many hundreds of trees of various ages were examined in this area, but on comparatively few were galls found, and even then only in small numbers. The one exception was the tree first mentioned, growing near the home of the writer at Lindfield.

Each year since 1933 this tree has carried countless thousands of galls. From May to December, 1936, many hundreds of galls were dissected in order to observe the stages of the various insects present and, in addition, in the spring 2,668 galls were picked from the same tree in order to obtain detailed emergence records, and yet all these galls represented only an infinitesimal proportion of the total number of galls originally on the tree. Thus it was possible to make periodical dissections of large numbers of galls over a twelve months period, without unduly diminishing the insect population, and this original heavily-galled tree has been utilized for practically all the investigations set out in this paper.

Trees of the same variety of *Acacia* have been growing within sixty yards of this tree, which has been galled for a number of years, and yet no galls have ever been found on these. At the time Cameron (1912) described *Tepperella trilineata* it was stated to have been bred from galls on *Acacia decurrens*, but no evidence was brought forward to show that, of the many species occurring in the galls, *T. trilineata* was really responsible for the primary gall formation.

In the spring of 1936, as the three main species emerged from the galls, numbers of each were enclosed in large cellophane sleeves on twigs and limbs of vigorous growing young acacias of the same variety growing in the home of the writer, and which, at the time, were free of galls. Small sleeves fifteen inches in length and six inches in diameter, and larger sleeves up to three feet in length and one foot in diameter, were used in these experiments, and altogether many hundreds of adult wasps of the three species were used. It was found that females of *Tepperella trilineata* would readily oviposit in the minute flower buds, but *Megastigmus* sp. and *Eurytoma* sp. never oviposited when enclosed with similar uninfested limbs. It was noted in these tests that when the adults of *T. trilineata* were first enclosed in these cellophane sleeves, they, in most cases, made their way to the top of the sleeve, and displayed no interest though suitable buds for oviposition were only a few inches away. To ensure that oviposition took place it was found advisable to use a camel-hair brush and with the point of this, transfer

the adult females direct from the tubes to suitable buds, and they then, usually, immediately commenced to oviposit.

T. trilineata females also oviposited readily in small buds picked off uninfested trees and enclosed in small glass tubes two inches in length and half an inch in diameter. However, in spite of this heavy oviposition by *T. trilineata*, most of the flower buds on these enclosed branches blossomed and fell, and though some flowers appeared to be slightly aborted, no galls developed on these vigorous young trees.

In the spring of 1937, at the time the adults commenced to emerge, and periodically for the next six weeks, twigs bearing large numbers of galls were tied to the uninfested *A. decurrens* trees of the same variety, growing in the writer's home, but again no galls formed. In 1936 and again in 1937, these young trees flowered within a few days of the heavily-galled tree, so that abundant buds at a suitable stage for oviposition were available. Factors inhibiting the production of galls on these trees are not clear. It is possibly connected with a condition of the sap in the young vigorous-growing trees, while the possibility of the existence of strains within the variety *pauciglandulosa* must not be overlooked.

Though the writer has not experimentally produced galls using *Tepperella trilineata*, there are many points which indicate its primary character. In the first place, it was the only species tested which would oviposit in acacia buds in which no other species had previously laid. Again, during the course of the work, thousands of gall cells were examined and, at least early in the development of the galls, *T. trilineata* was present in all gall cells. In many typical galls *T. trilineata* was the only species found, and examination of cells in these particular galls failed to reveal any evidence of any other species ever having been present.

It was found that when the acacia bud galls were in their very early stages and when the wasps were in the minute egg or early larval stages, even dissection with fine scalpels and needles under the microscope was extraordinarily difficult. The exact location of the insects in the galls could never be determined and they were frequently injured or destroyed during the dissection. Eventually the writer found that by holding the buds in the fingers under the high power of the binocular microscope and, with a razor, cutting extremely thin sections off the gall, it was possible to cut down until portion of the insect egg or larva was just visible. With the point of a cataract knife the plant tissues could then be chipped away and the egg or larva could eventually be completely exposed, and usually was in an uninjured condition.

The species under discussion is at present placed in the family Perilampidae, but both Dr. A. B. Gahan and Mr. A. A. Girault, formerly of the Queensland Department of Agriculture, have informed the writer that they doubt the correctness of this placement. The genus *Tepperella* was established by Cameron (1911), the type species being *T. maculiscutis*, which was bred from galls on *Eucalyptus leucoxylon* in South Australia. Since that time *T. trilineata* has been described, but these are the only two species so far recorded in this genus. Thus the genus is at present confined to Australia and both the species so far recorded have been bred from galls.

T. trilineata has been recorded from Tasmania and Victoria (Cameron, 1912), and the writer has bred this species from galls on *Acacia decurrens* collected at Wyong on the Coast, Blaxland on the Blue Mountains, and Bathurst on the Central Tablelands of New South Wales.

Morphology.

The Adult.

♀.—The adult female (Fig. 1) which was described by Cameron (1912) is a rather robust yellow and black wasp. Its average length is 2·76 mm., the maximum being 2·97 mm. and the minimum 2·55 mm. When at rest it has the abdomen deflected downwards at an angle to the thorax. When alive, the eyes and ocelli

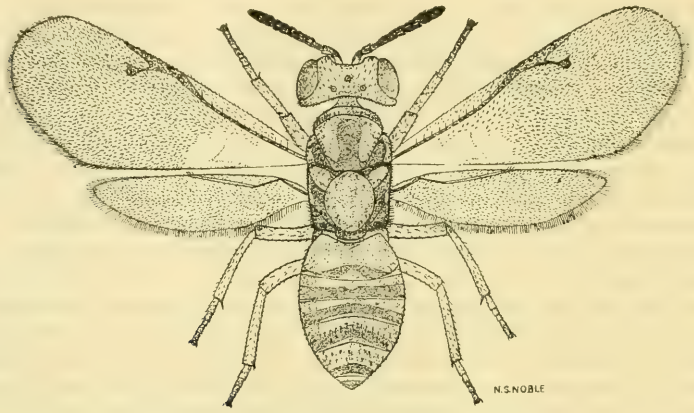

Fig. 1.—*Tepperella trilineata.* Adult female, × 15.

are reddish-brown, the antennae are dark brown and the head is mainly yellow with the tips of the mandibles dark brown. The back of the head is black. The base of the scutum is black and a variable central broad band on the scutum is black. This band may extend to the narrow pronotum or it may terminate before it, and its width is variable.

The dorsal surface of the pronotum is black and the ventral surface yellow. A fairly large proportion of the parapsides are black adjoining the scutum. The axillae on their outer margins and where they adjoin the scutum are black, the remainder being yellow. The scutellum is yellow with the hind margin black, the rest of the thorax being black. The legs are yellow, and the head, thorax and legs bear dark brown or black setae which stand out conspicuously. On the scutellum there are ten such setae, five being on each side in two somewhat irregular rows.

The dorsal surface of the abdomen consists of a series of black and yellow bands, with the tip of the abdomen black. Ventrally and distally the abdomen is black with the basal half yellow, the amount of black colouring on the abdomen and also the thorax differing considerably in different individuals.

♂.—The male is not mentioned in the original description, and, on account of the remarkable sexual dimorphism exhibited in this species, the male could easily be superficially mistaken for another species.

The average length of the male is 2·24 mm., the maximum being 2·45 mm. and the minimum 1·98 mm. It is, thus, on an average, approximately half a millimetre shorter than the female, but the male is very much less robust, this being particularly true of the abdomen, so that in general appearance the male is a very much more slender insect than the female.

The eyes of the male are reddish-brown, the antennae are brown and the remainder of the head and the thorax are black. The abdomen varies from brown to dark brown. The coxae and the distal half of the last segment of the tarsus and the tarsal claws are dark brown or black, the remainder of the legs being yellow. The wings are fuscous.

Other Morphological Characters of the Adult.

The stigmal knob (Fig. 2*c*), antenna (Fig. 2*b*) and mandible (Fig. 2*f*) of the female, the antenna (Fig. 2*a*) of the male and the tips of the stylet (Fig. 2*d*) and ovipositor sheath (Fig. 2*e*) of *T. trilineata* are illustrated. It will be noted that the tip of the stylet, though sharp pointed, bears no barbs, nor are any barbs present on the tip of the ovipositor sheath.

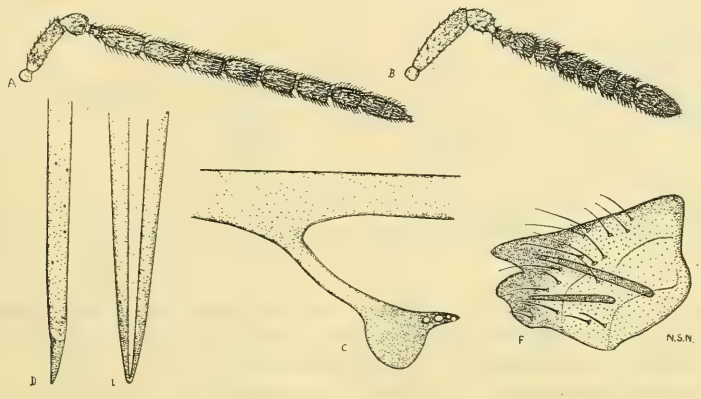

Fig. 2.—*Tepperella trilineata.* A, Antenna of male, × 36; B, Antenna of female, × 36; C, Stigmal knob of female, × 103; D, Lateral view of ovipositor stylet, × 180; E, Ventral view of ovipositor sheath, × 180; F, Mandible of female, × 103.

The Egg.

On dissecting the abdomen of a newly-emerged female, eggs floated out in large numbers in the dissecting solution, and could readily be studied.

Females were also enclosed in small tubes with acacia flower buds and as soon as oviposition occurred the buds were dissected and the newly deposited eggs were then examined.

The ovarian egg (Figs. 3*a*, *b*, *c*, *d*) is white in colour and consists of two oval bodies joined by a narrow connecting tube. In the earlier stage of development this tube is folded so that the two bodies lie near one another, but prior to deposition this tube becomes extended (Figs. 3*c*, 3*d*). The surface of the egg is smooth and unornamented. Immediately after deposition it is found that all the protoplasmic contents have passed into one end of the egg (Figs. 3*e*, 3*f*). The newly deposited egg, which is white in colour, consists of an oval body with a long flaccid pedicel. The presence of a long pedicel on the eggs of Chalcids has often been noted, but in *T. trilineata* the development of this pedicel has been carried to such a stage that the pedicel is just as voluminous as the main body of the egg.

As the protoplasmic contents all pass to one end of the egg after deposition, there is little doubt that this double-ended egg development is a device for facilitating the passage of the egg down the narrow ovipositor.

Bilobed ovarian eggs occur in some species of Chalcids, but the great length of the narrow connecting tube in *T. trilineata* is unusual. A somewhat similar type of egg has been described by Smith and Compere (1928) in *Metaphycus*

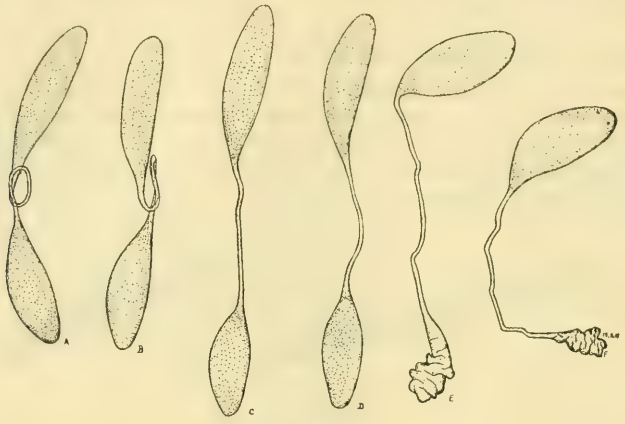

Fig. 3.—*Tepperella trilineata*. A, B, Ovarian eggs with connecting tube folded; C, D, Ovarian eggs with connecting tubes extended; E, F, Eggs just after deposition. All × 103.

lounsburyi, a parasite of the black scale, *Saissetia oleae*, but in this instance the elongate pedicel, after deposition, serves as a respiratory tube for the larva and projects through the integument of the scale insect.

The detailed dimensions of the egg of *T. trilineata* are set out in Table 1.

TABLE 1.

Dimensions of egg of Tepperella trilineata *(in millimetres).*

	Eggs dissected from ovaries.						Connecting tube.		Eggs immediately after deposition.	
			Larger body.		Smaller body.					
	Length with connecting tube folded.	Length with connecting tube extended.	Length.	Width.	Length.	Width.	Length.	Width.	Body Length.	Body Width.
Average	0·400	0·506	0·179	0·050	0·138	0·051	0·190	0·004	0·168	0·071
Maximum	0·432	0·521	0·185	0·053	0·142	0·053	0·205	0·004	0·186	0·078
Minimum	0·368	0·498	0·172	0·033	0·132	0·046	0·185	0·004	0·156	0·055

The Larva.

Based on the arrangement of the setae and papillae on the head, the size and shape of the mandibles, the number and size of the spiracles, and the distribution of setae on the body segments, it is evident that there are five larval stages.

Parker (1924) stated that in species of the family Perilampidae there were four larval stages including the first or "planidium" or roving stage.

Dr. A. B. Gahan informed the writer that in his opinion these Australian gall-forming Chalcids form an analogous group and that their present systematic placement is unsatisfactory, and that a special group will probably have to be

erected for them. Gahan's opinion has been arrived at from taxonomic studies, and the present biological studies of the writer lend further support to Gahan's opinion.

Stage I.—The first stage or primary larva (Fig. 4) is more or less translucent, with the contents of the alimentary tract bright green. It consists of a head and thirteen segments, but segmentation is not distinct. The head is hemispherical in outline, and is much narrower than the anterior abdominal segments and is relatively inconspicuous. The second and third abdominal segments are the widest portion of the larva, but it is more or less cylindrical and straight and narrows only slightly in the posterior segments. The mandibles are very minute, pale amber, more or less triangular in outline and average 0·008 mm. in length, and their tips overlie one another (Fig. 8*a*). The average width, between the two anterior tentorial rami (Vance and Smith, 1933), is 0·040 mm. The integument of

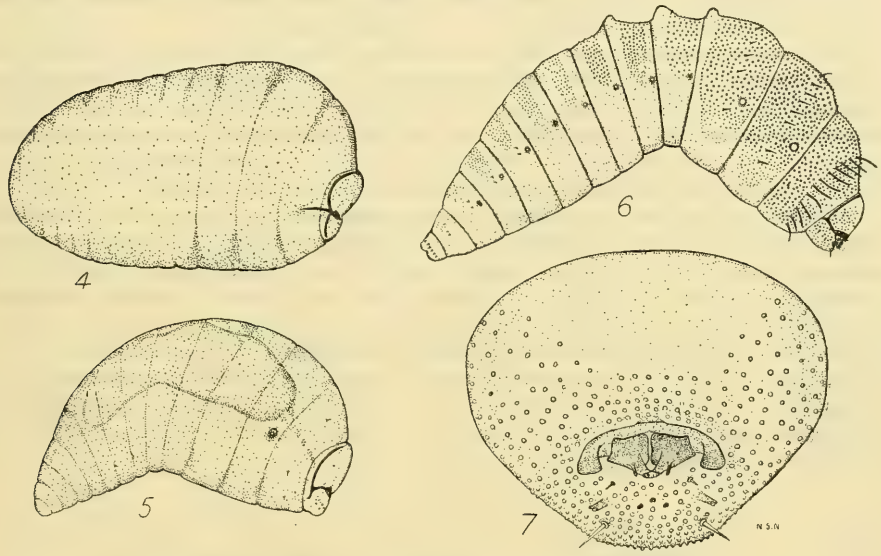

Fig. 4.—*Tepperella trilineata.* Lateral view of first-stage larva, × 180.
Fig. 5.—*Tepperella trilineata.* Lateral view of third-stage larva, × 55.
Fig. 6.—*Tepperella trilineata.* Lateral view of mature larva, × 20.
Fig. 7.—*Tepperella trilineata.* Front view of head of mature larva, × 103.

the body is smooth and glistening and free of spines. On the underside of the head are five minute sensillae, but no setae are present. There is no evidence of any respiratory system.

The smallest larva measured was 0·19 mm. in length and 0·08 mm. in width, being just visible to the unaided eye.

Stage II.—In colour and shape the second stage larva is remarkably similar to that of the first stage, but the two can be distinguished in a number of ways. The smallest larva measured was 0·22 mm. in length and 0·17 mm. in width. The mandibles (Fig. 8*a*) are amber in colour, more or less triangular in outline, with one sharp point. They average 0·016 mm. in length. In addition to the papillae below the mouth, two minute lateral setae are distinguishable and these average 0·003 mm. in length. There are no setae on the abdominal segments, but there is

now a limited respiratory system present. This consists of a pair of longitudinal tracheal trunks, a few minute branches and one pair of open spiracles situated on the second segment and averaging 0·01 mm. in diameter.

The width between the two anterior tentorial rami is 0·109 mm. or about three times the width of stage I.

Stage III.—The third stage larva (Fig. 5) is somewhat translucent to light green in colour, cylindrical, arched and tapering to both ends. The smallest larva measured was 0·40 mm. in length and 0·22 mm. in width. It consists of a head and thirteen clearly defined segments. The mandibles (Fig. 8*c*) are amber in colour, much the same shape as those of the second stage. Their average length is 0·023 mm., the maximum being 0·026 mm. and the minimum 0·021 mm. A limited number of extremely minute papillae are to be seen on the ventral surface of the first abdominal segment. Sensillae are present beneath the mouth as in the second stage, and there is also a lateral pair of setae which are 0·006 mm., or just twice the length of those present in the second stage.

On the first segment there is a median circlet of very short straight setae, the number being variable, their average length being 0·017 mm. The remaining segments bear no setae. The respiratory system is very similar to that of the second stage, there still being but one pair of open spiracles on the second segment, their average diameter being 0·018 mm. In the more advanced larvae of this stage a pair of spiracles can be seen developing on the third segment.

Stage IV.—The fourth stage larva is greyish-green in colour, with the region of the alimentary tract darker green. Towards the close of this stage the larva becomes more white in colour, mainly due to the presence of fat body. It is cylindrical, arched and tapering towards both ends, and in general outlines resembles the larva of the last stage. It consists of a head and thirteen segments. The smallest larva measured was 0·58 mm. in length and 0·32 mm. in width. The mandibles (Fig. 8*d*), which are dark amber in colour, are more or less triangular in outline with very broad bases and one pointed, curved and more heavily chitinized tooth. Their average length is 0·039 mm., the maximum being 0·046 mm. and the minimum 0·036 mm.

TABLE 2.

Length of life of Tepperella trilineata *in laboratory.*

Length of life in days.	Number of Females.	Number of Males.
1	1	6
2	15	17
3	16	21
4	28	42
5	44	44
6	25	44
7	31	31
8	40	19
9	30	18
10	11	6
11	3	1
12	4	—
13	1	1
14	1	—
Total	250	250

Average length of life of male wasps, 5·48 days; female wasps. 6·34 days.
Maximum length of life of male wasps, 13·0 days: female wasps. 14·0 days.
Minimum length of life of male wasps, 1·0 day : female wasps. 1·0 day.

Below the mandibles and a little above them, the integument bears a number of minute papillae. Similar papillae can be distinguished on the first and second segments, but they can only just be seen with the highest power of the microscope on the second abdominal segment, and if present on the posterior segments, they are too minute to distinguish. On the head and below the mandibles there is a pair of minute setae and below these a pair of minute truncate cone-shaped structures, between which there are three oval sensillae and below these again there is a pair of longer setae, their average length being 0·017 mm.

On the first segment of the abdomen there is a median circlet of straight setae, the number usually being sixteen. The length of these setae varied on different larvae, the largest being 0·036 mm. in length and the smallest being 0·025 mm. in length. There are six shorter setae on the second segment, these being dorsal and lateral, and there are four minute lateral setae on the third segment. On segments nine to twelve there are two extremely minute lateral setae and on the last segment there are at least four.

There is further development of the respiratory system in this stage. In the more advanced larvae nine pairs of spiracles can be seen developing, but the first and second pair are larger than the rest and these are the only two which appear to open during this stage. The tracheal branches passing to the various organs are now more numerous.

Stage V.—The fifth or last stage larva (Fig. 6), which is white in colour, is cylindrical and arched, and tapering towards both ends. The average length of the mature larva is 3·25 mm., the average width being 0·84 mm. The dimensions of the largest and smallest larvae measured are set out in Table 3.

TABLE 3.

Dimensions (in millimetres) of various larval stages of Tepperella trilineata.

Stage of larva.		Length.	Width.
Stage I	Largest	0·28	0·17
	Smallest	0·19	0·08
Stage II	Largest	0·53	0·30
	Smallest	0·22	0·17
Stage III	Largest	0·77	0·32
	Smallest	0·40	0·22
Stage IV	Largest	1·04	0·40
	Smallest	0·58	0·32
Stage V	Largest	3·39	1·09
	Smallest	0·75	0·35

It consists of a head and thirteen segments, the head being rather inconspicuous and narrower than the anterior abdominal segments. Dorsally on the third, fourth and fifth segments there are ridges which become less prominent as the larva matures. Below and for some distance above the mandibles on the head (Fig. 7) and all over the surface of the first segment and laterally and dorsally on the succeeding segments, there are large numbers of rounded papillae, which become smaller and less numerous and more confined to the dorsal surface on the posterior segments.

On the first segment there is a complete girdle of long setae (Figs. 8*e*, *f*, *g*), which arise from papillae, which are chitinized, amber in colour, variable in

number, and have the tips truncate. The setae on the first segment are frequently curved in outline, and vary somewhat in length, even on the same larva, but their length on different larvae varies greatly. Their average length on different larvae was found to be 0·098 mm., the maximum being 0·139 mm. and the minimum 0·059 mm. On the second and third segments a large number of setae are present, but they are much shorter than those on the first segment, their tips are not truncate, and they are borne dorsally and laterally, but not ventrally. On the fourth to the seventh segment inclusive, there are no setae. Occasionally on the eighth segment there is one short seta in the vicinity of the spiracle, and on segments nine to twelve, inclusive, there are commonly two pairs of short lateral setae, but the number on each side may vary from one to three. On the thirteenth segment there is a conspicuous girdle of short setae. A depression on the thirteenth segment marks the position of the anus. The first three segments are conspicuously wider than the succeeding ones. The head is more or less semicircular in outline (Fig. 7), and is more heavily chitinized than the remainder of the larva.

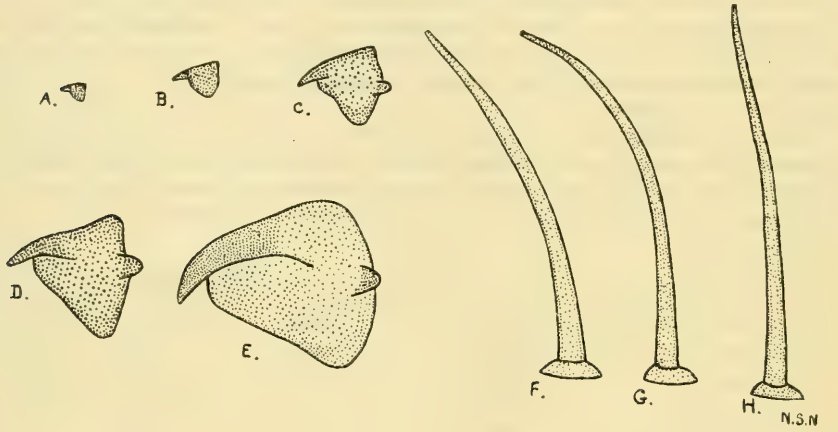

Fig. 8.—*Tepperella trilineata.* A, Mandible of first-stage larva; B, Mandible of second-stage larva; C, Mandible of third-stage larva; D, Mandible of fourth-stage larva; E, Mandible of fifth-stage larva; F, G, H, Setae from first segment of mature larva. All × 180.

The mandibles, the tips of which overlie one another, are light brown in colour, somewhat triangular in outline with one prominent curved more heavily chitinized tooth (Fig. 8*e*). They are variable in size, the average length being 0·064 mm., the maximum being 0·076 mm. and the minimum 0·056 mm. No evidence of antennae could be distinguished above the mandibles. Below the mandibles there is one pair of short setae and slightly below these, and more widely separated, is a pair of short truncate cone-shaped chitinized structures, the function of which is unknown. Below these there are three oval papillae, and below there is one pair of larger setae.

The tracheal system is now a complete and open one and consists of two well-developed longitudinal tracheal trunks extending down each side of the body, united anteriorly and posteriorly by short transverse trunks. Nine pairs of spiracles are present, being situated on the anterior part of each segment from two to ten, inclusive; the spiracles project slightly from the general body surface. The spiracles on the second segment are larger than any of those succeeding,

while those on the third segment are extremely minute and appear to be almost non-functional. From the main tracheal trunks profusely branching tracheae pass out to the various body organs.

The dimensions of the smallest and largest larvae of the various stages measured are set out in connection with larval development in Table 3.

Biology.

Length of Life of Adults.

A total of 500 newly-emerged males and females of *T. trilineata* were placed in glass tubes six inches in length and one inch in diameter. One end of the tube was covered with cheese-cloth and the other was plugged with cotton-wool which was kept moistened with sugar and water solution. These were held in the laboratory and dead wasps were removed daily; the length of life of males and females under these conditions is set out in Table 2. Females lived slightly longer than males, but the length of life of both sexes was comparatively short.

In the spring of 1936 ten females were used to obtain oviposition records and were kept in tubes and provided with fresh acacia flower buds during their entire adult lives. The number of days these adults lived was as follows: 2, 2·5, 2·5, 3, 3·5, 4·5, 4·5, 4·5, 5, and 5, the average being 3·7 days, so that the life of ovipositing females is very short.

In the series of experiments mentioned in the introduction, in which many hundreds of newly-emerged adults were enclosed on acacia branches in cellophane sleeves, many died during the first twenty-four hours, and it was exceptional to find any adults living after the fourth day.

Habits of Adults.

Both sexes are somewhat inactive as compared with the other species in the galls. They tend to walk rather than fly and can readily be transferred in the laboratory by means of a camel-hair brush. During the heat of the day in the open, they are fairly active, and have been observed flying in large numbers around the tree bearing the galls from which they emerged. They are not strong fliers and soon settle after taking to the wing. At night they have been found sheltering in flower-buds or beneath leaves. When confined in glass tubes they have sometimes been observed feeding on sugar and water solution, but they are not particularly attracted to this food.

Percentage of Sexes.

Of a total of 1,058 adults of *T. trilineata*, which emerged from galls in the spring of 1936, 525 or 49·62 per cent. were females and 533 or 50·38 per cent. were males, the ratio of sexes being therefore remarkably even.

Mating.

T. trilineata does not mate readily in the laboratory. Although 500 individuals of both sexes were enclosed in tubes, six inches long and one inch in diameter, when determining the length of life it was only on rare occasions that fertilization was observed. Even when females known to be unfertilized were enclosed with males in very small vials, the two sexes were not attracted to one another. Fertilization was observed on a number of occasions, but there was nothing unusual worthy of record. In one instance the contact lasted thirty-five seconds.

Oviposition.

At the time the first adults of *T. trilineata* emerge only the more advanced flower buds are showing and these are so small that only microscopic examination indicates their nature. The complete inflorescence at this time consists of one

minute compact mass, which will eventually separate into a number of globular green flower-heads, each on a short stalk. The females oviposit in these flower buds, but never display any interest in the inflorescence once the individual globular flower-heads have become separated from one another.

Whether fertilized or unfertilized, immediately upon eating their way out of the galls, females may commence to oviposit. Adults which emerged from pupae dissected and placed in petri dishes, on dissection were found to contain very few mature eggs, while females dissected immediately after emerging from galls were found to have the majority of the eggs mature. Evidently, as the writer (Noble, 1936) found in *Eurytoma fellis* in citrus galls, the adults take some days to eat their way out of the galls and during this period the eggs mature, and the wasp is able to lay large numbers of eggs during the first day of emergence.

The ovipositing female, on coming into contact with a suitable flower bud (Plate xx, fig. 1) becomes very excited and, for a few moments only, plays the tips of the antennae over the surface of the bud. Without inflexing the abdomen the wasp independently thrusts the ovipositor from beneath the guards and brings it down at right angles to the body, so that its tip rests on the surface of the bud. It experiences little difficulty in penetrating the plant tissues, but for the earlier part of the oviposition period the ovipositor is only partly embedded. Later the ovipositor is moved up and down; the abdomen is moved from side to side and the ovipositor is then embedded more deeply and, before finally withdrawing it, the wasp remains motionless for a few moments. Usually on withdrawing the ovipositor the latter is not replaced within its guards, but is held down at right angles to the body, with its tip poised just above the plant tissues. The wasp then moves slightly forward and again penetrates the bud and lays another egg, the ovipositor being again withdrawn, and the process repeated. Unsuccessful attempts to oviposit, accompanied by a partial embedding of the ovipositor, were rarely observed, and in the laboratory the female usually oviposited almost continuously for some hours without leaving the buds to rest. Two females under observation oviposited continuously for four and three-quarter hours, and five and one-quarter hours, respectively, and both were actively ovipositing on the following day. The time occupied in individual ovipositions, both by the same and by different females, varied considerably, the recorded times of eight ovipositions being 6, 8, 2, 3, 2, 6, 2, and 3 minutes.

It is of interest to note that once the female has discovered a suitable bud-mass by means of the antennae, the latter appendages are seldom again utilized, while the female remains ovipositing on that particular bud-mass.

A number of eggs is laid in each globular flower-head, and each one of these minute globular heads eventually forms a gall. Five globular heads were dissected and found to contain 6, 5, 8, 7 and 5 eggs respectively; one flower-bud which measured 0·75 mm. in diameter contained five eggs. The eggs in many instances are separated slightly from one another, but frequently eggs are touching.

Ten females were confined in tubes from emergence until death and were regularly supplied with fresh acacia buds in which to oviposit. In all cases eggs were laid until within a few hours of death, the average length of the oviposition period being 3·5 days, with a maximum of 5 days and a minimum of two days. In all but one case, dissection showed that the dead females contained large numbers of apparently normal eggs.

As the first adults emerged on 7th September and the last emergence occurred on 12th October, 1936, and the maximum length of life was only fourteen days, the total period of oviposition in 1936 was almost two months, and terminated

about the end of October. Throughout the latter half of September and the first half of October, 1936, females were observed in large numbers, on sunny days, flying about the galled tree or ovipositing in the minute flower-buds.

Total Eggs Within Females.

Ten newly-emerged females were dissected and were found to contain the following numbers of eggs: 495, 519, 552, 561, 456, 542, 565, 461, 611, 578, the average number being 534, which is considerably more than the number of eggs present in any other species of Chalcid previously studied by the writer.

Incubation Period.

As with other gall species, it is impossible to determine accurately the incubation period, as dissection of the egg from the plant tissues results in its destruction. Observations must therefore be of an indirect character.

On 4th October, 1936, twenty-seven days after the first adult of *T. trilineata* emerged, a number of the more advanced acacia buds were dissected and, while mostly eggs were found, one minute first-stage larva was dissected, while in several eggs fully-developed larvae could be seen. The incubation period of this larva was at most twenty-seven days.

On 19th October, 1936, six weeks after the first adult emerged, many eggs and first stage larvae were dissected from acacia buds and some of these larvae were considerably larger than those dissected two weeks earlier.

Larval Development.

It has already been pointed out, when discussing the morphology, that there are five larval stages. The first-stage larva, on first hatching, is somewhat arched and flaccid, but as it feeds and increases in size (Fig. 4) it becomes straight in outline and the head becomes relatively inconspicuous. At no stage do the larvae possess any powers of locomotion, but all twist and turn slowly when dissected from the plant tissues. On changing to the second stage the larva becomes longer in proportion to its width. The earlier stages are semi-translucent with the region of the alimentary tract green, due apparently to the green cell contents of the nutritive layer on which these larvae feed. In the fourth stage, and particularly in the fifth or last larval stage, fat-body develops so that eventually the stomach contents are so masked that the larva appears to be white in colour.

In the earlier stages the stomach is a blind sac and the alimentary tract does not open to the exterior until the larva reaches maturity, and any waste matter is voided prior to pupation. On mounting larvae of the last stage it is quite common to find the mandibles and cast skins of all the preceding stages adhering to the integument.

During 1936 and 1937 large numbers of larvae of various stages were measured. In Table 3, the dimensions of the largest and smallest larvae of the various stages are set out. As with other larvae studied by the writer, the amount of growth during the fifth stage is outstanding.

There is considerable overlapping of size in the various stages, some of the immature larvae of any stage being smaller than fully-fed larvae of preceding stages. Adult females of *T. trilineata* are much larger than male adults, and the smaller measurements are probably, in many cases, those of larvae which would have given rise to males.

In Table 4 is set out the result of the periodic dissections of galls on *Acacia decurrens* at Lindfield in 1936 and 1937. As the adults of the gall former, *T. trilineata*, emerge each year in September and October, the figures in the table represent observations on two generations of larvae.

TABLE 4.

Results of dissections of Galls on Acacia decurrens *throughout a period of sixteen months (May, 1936–September, 1937) showing stages of* Tepperella trilineata *present.*

Date of dissection.	Number of cells containing *T. trilineata* examined.	Stage I.	Stage II.	Stage III.	Stage IV.	Stage V.	Number of prepupae.	Number of pupae.	Number of adults.	Remarks.
					1935–36 Galls.					
11/5/36	15	—	1	1	12	1	—	—	—	
16/5/36	8	—	—	—	3	5	—	—	—	
27/5/36	25	—	—	—	22	3	—	—	—	
5/6/36	11	—	—	—	—	11	—	—	—	
19/6/36	1	—	—	—	—	1	—	—	—	
26/6/36	13	—	—	—	—	13	—	—	—	
3/7/36	5	—	—	—	—	5	—	—	—	
8/7/36	25	—	—	—	—	25	—	—	—	Only 3 mature.
11/7/36	17	—	—	4	1	11	1	—	—	
16/7/36	14	—	—	3	2	9	—	—	—	
26/7/36	35	—	—	—	—	30	5	—	—	
28/7/36	17	—	—	—	1	13	2	1	—	
3/8/36	21	—	—	—	—	—	8	13	—	
9/8/36	26	—	—	—	—	13	7	6	—	
12/8/36	24	—	—	4	2	18	—	—	—	
18/8/36	21	—	—	—	—	—	—	21	—	
22/8/36	27	—	—	—	—	—	8	19	—	
30/8/36	40	—	—	—	—	—	9	30	1	
6/9/36	45	—	—	—	—	2	—	40	3	
9/9/36	13	—	—	—	—	—	—	12	1	
13/9/36	23	—	—	—	—	—	—	14	9	First emergence holes present.
20/9/36	12	—	—	—	—	—	—	2	10	}
27/9/36	12	—	—	—	—	—	—	1	11	} Large number of emergence
*4/10/36	8	—	—	—	—	—	—	4	4	} holes present.
					1936–37 Galls.					
27/9/36	Not counted	—	—	—	—	—	—	—	—	Eggs only.
4/10/36	,,	1	—	—	—	—	—	—	—	}
19/10/36	,,	3	—	—	—	—	—	—	—	} Large number of eggs present.
29/11/36	,,	4	—	—	—	—	—	—	—	A few eggs present.
5/12/36	,,	†	—	—	1	—	—	—	—	No eggs.
14/12/36	6	4	1	1	—	—	—	—	—	
9/1/37	4	3	1	—	—	—	—	—	—	
16/1/37	8	6	2	—	—	—	—	—	—	
1/2/37	7	7	—	—	—	—	—	—	—	
15/2/37	6	2	4	—	—	—	—	—	—	
9/3/37	11	—	6	1	2	2	—	—	—	
2/4/37	9	—	1	8	—	—	—	—	—	
20/4/37	13	—	—	12	1	—	—	—	—	
7/5/37	26	—	1	14	10	1	—	—	—	
1/6/37	15	—	—	1	11	3	—	—	—	
29/6/37	38	—	—	1	2	35	—	—	—	
15/7/37	29	—	—	—	—	29	—	—	—	
6/8/37	17	—	—	—	—	14	3	—	—	
13/8/37	46	—	—	—	—	40	2	4	—	
30/8/37	27	—	—	1	—	10	1	15	—	
14/9/37	13	—	—	—	—	—	—	12	1	
16/9/37	79	—	—	—	—	—	—	72	7	

*1936 First adult of *T. trilineata* emerged 7th September.
1936 Last ,, ,, ,, ,, 12th October.
1937 First ,, ,, ,, ,, 19th September.

On 11th October, 1936, 106 gall cells were examined and on 18th October, 1936, a further 153 cells were examined, but no adults of *T. trilineata* were found.

†Large number.

The Pupal Stage.

On first pupating the female pupae are white, but change within a few days to shining black. The average length of the female pupa is 2·61 mm., the maximum being 2·76 mm. and the minimum 2·45 mm.

Male pupae are to be found in much smaller cells scattered through the galls, the plant tissues fitting closely up against the integument of the pupa. Sometimes these male cells have a very thin layer of plant tissue separating them from the exterior, but frequently they are deep down within the galls, usually in close proximity to much larger cells containing the females.

Male pupae at pupation are creamy-white, their average length being 2·04 mm., the maximum being 2·19 mm. and the minimum 1·79 mm. Unlike the female, they do not change colour rapidly during the pupal period. The colour remains creamy-white for approximately three weeks. The antennae then become amber; the eyes turn reddish-brown, the remainder of the pupa becoming pigmented only a few days before emergence, the general colour then being dark-brown with alternating light and dark brown bands on the abdomen. Unlike the female, the male pupa never becomes black.

In 1936 the first pupa of *T. trilineata* was found in a gall on 28th July, and it subsequently emerged on 20th August, eighteen days before any adults ate their way out of the galls. In the spring of 1936 large numbers of prepupae were dissected from galls and placed in petri dishes, a high humidity being maintained by placing a large saturated cotton-wool plug in the dish. Most of these prepupae died, but four pupated and later emerged as adults, the pupal periods being 37, 41, 38 and 40 days, the average being 39 days.

Four pupae of *T. trilineata* were found in galls on 13th August, 1937, sixteen days later than the first pupa was found in the preceding year. The date of pupation of these individuals was, of course, not known, but it will be noted that there was also a difference of 12 days in the dates of first emergence of adults in 1936 and 1937.

In 1937 pupae were again dissected out of galls and held in petri dishes and three emerged as adults on 14th September, which is 25 days later than the first adult emerged, under these conditions, in 1936.

Emergence of Adults.

Adults emerge by cutting a cylindrical channel from the gall chamber to the exterior, leaving a regular circular hole on the gall surface.

In order to obtain seasonal emergence records, large numbers of galls were picked from the tree a few days before any adults emerged. These galls were placed in large tubes 8 inches in length and 1½ inches in diameter, and the end was plugged with cotton wool moistened with water. In these tubes the galls remained quite green and unshrivelled for several weeks.

In figure 9 is shown graphically the daily emergence of 1,058 adults of *T. trilineata* in the spring of 1936. The first emergence occurred on 7th September and the last on 12th October, the total emergence period being thirty-six days.

Early in the spring 200 pupae of *T. trilineata* were dissected from galls and placed in petri dishes and the first of these emerged as an adult on 20th August, eighteen days before the first adult emerged from the galls. An adult was also found in a gall on 30th August, 1936, eight days before any adults ate their way out, so it is evident that the adults on emerging from the pupal stage require some days to cut their way out of the galls. In 1937 the first adult emerged from galls on the same tree on 19th September, which was twelve days later than in the preceding year.

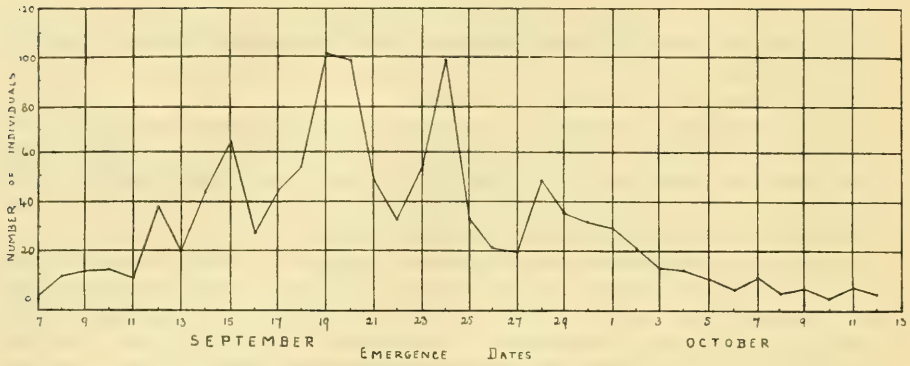

Fig. 9.—Graph showing emergence of 1,058 adults of *Tepperella trilineata* at Lindfield, Sydney, in the spring of 1936.

Natural Mortality.

Occasionally in dissecting galls in the late winter and spring of 1936 cells were found in which dead larvae or pupae of *T. trilineata* were present, while on a number of occasions dead adults of both sexes were found in cells, no attempt having been made, after passing from the pupal stage, to eat their way out of the galls.

Time Spent in the Various Stages of the Life Cycle.

In Table 4 are set out the results of the dissections of galls in 1936 and 1937, and as the adults emerge in September and October, these figures represent observations on two generations of *T. trilineata*, those of 1936–37, covering the complete life-cycle of this generation. The figures indicate the progressive development of the various stages of the insect.

It will be seen that first-stage larvae were present from 4th October, 1936, to 15th February, 1937, a period of almost four and a half months, a considerable period, but far less than the writer (Noble, 1936) found in the citrus gall wasp, *Eurytoma fellis*. In that species, though adults emerged annually and in the spring, the larvae of *E. fellis* remained in the first larval stage for a period of eight months.

Second-stage larvae were present from 14th December, 1936, to 7th May, 1937, a period of more than four months, and the last second-stage larva was found in the previous generation as late as 12th August, 1936, so it is evident that the length of time spent in this stage is very variable.

Third-stage larvae were first found in the galls on the 14th December, 1936, and in the previous generation were present until 12th August, 1936, and one was also found on 30th August, 1937.

Fourth-stage larvae were first found on 5th December, 1936, and in the previous generation they were present until 12th August, 1936.

In the case of the last stage, the first larva was found on 9th March, 1937, and larvae of this stage were present until 30th August, 1937. In the previous generation of galls they were present from 11th May, 1936, the first date on which detailed observations were made, until 6th September, 1936, a few days before the first adults emerged. All fifth-stage larvae dissected on 26th July, 1936, and subsequently, were mature.

It is therefore evident that, as in the second stage, there is very great overlapping in the periods spent in the third, fourth and fifth larval stages. The

immature larvae, which were occasionally dissected long after the majority of the same stage were found, were taken from very minute galls, and it is doubtful if these larvae would ever have matured.

Allowing for a twelve-months life-cycle, an incubation period of approximately four weeks and a pupal period of almost six weeks, it is evident that the larval period extends over a period of approximately ten months, being, as with the citrus gall wasp, *Eurytoma fellis*, by far the longest period of the life-cycle.

Observations on the Development of the Galls.

In *Acacia decurrens* the inflorescence consists of a number of globular flower-heads, each head or "ball" consisting of a number of flowers.

At the first appearance of the flowering buds these bright green globular flower-heads are close together, forming a compact mass (Plate xx, fig. 1), but just prior to flowering each globular head separates from its neighbour and is attached by a short stalk to the main stem of the inflorescence.

It has already been stated that in 1936 the emergence of *Tepperella trilineata* commenced on 7th September, and continued until 12th October. On 7th September that year the more advanced flower buds were just beginning to appear.

By 27th September a large number of flower buds were present and in the more advanced inflorescences, the individual flower-heads had separated out, but in the majority the globular flower-heads still formed one compact mass.

By 11th October, most of the globular flower-heads had separated from one another, but no flowers were present and there were still a few buds in which the globular flower-heads formed a compact mass, but this was exceptional. It is worthy of note that the last adult of *T. trilineata* emerged on the following day.

By 18th October there was still no sign of flowers, but most of the individual globular flower-heads were separated from one another on the inflorescence. Though it was forty-one days since the first adult gall-wasp emerged and oviposited and the incubation period that season was slightly less than four weeks, there was no observable sign of distortion of any of the buds.

A thorough inspection of the tree on 25th October showed general conditions exactly as they were one week before, there being no sign of flowering or evidence of galling of any of the globular flower-heads.

On 1st November conditions were much the same and on 8th November, while no flowers had yet appeared, most of the globular flower-heads were now very large and conspicuous and mainly separated from one another.

On 11th November no flowers were seen, but on the following day, 12th November, a little more than two months after the first flower-buds were noticed, the first globular heads bloomed, and by 15th November a number of the conspicuous golden heads were to be seen on different parts of the tree, but at this time only a small number of the inflorescences were in full bloom.

The individual flowers comprising a globular head pass out from a minute fleshy green base to which the flower stalk is attached. At this time it was noted that in some flower heads this fleshy base was slightly more prominent than usual and that in these only a small number of flowers, notably those most distant from the base, had flowered, and on dissection of the fleshy green zone, first-stage larvae of *T. trilineata* were found. Thus this abnormal flowering of certain buds provides the first indication that they are infested.

By 22nd November the tree was half in bloom and many of the earlier flower-heads had already shrivelled and fallen. By 29th November the tree was in full bloom, but there were still many buds to come out.

It was noted that in many inflorescences, though a high percentage of the flowers had shrivelled and fallen, those in which flowering had been abnormal and which were infested by *T. trilineata* remained attached to the flowering stems.

By 6th December the tree was past full bloom, but there were still many buds to open and the tree still presented a golden appearance.

On 13th December the tree was still in flower, but most of the buds had opened, and by 18th December, 1936, the tree had finished flowering, a few faded globular heads were still on the tree, but there were no further buds to open.

The distorted flower-heads in which *T. trilineata* larvae were present, though still quite small, had increased in size somewhat, and were readily observed, attached to the more or less bare flower stems, from which the normal flowers had fallen.

Thus the tree during 1936 was in flower for a period of five weeks and finished flowering approximately three and a half months after the first flower-buds were noticed. In 1937 the first blossom appeared on this tree, on 4th November, which was some days earlier than in the preceding year, and a few blossoms were still present on 20th December, 1937, which was also slightly later than in the preceding year, so that the flowering period in 1937 was somewhat more protracted than in 1936.

The first trace of abnormality in the flowers was noticed in flowers on 15th November, 1936, which was sixty-nine days after the first adult of *T. trilineata* emerged and oviposited. As the incubation period was about four weeks in 1936, it is evident that there are no external or internal signs of distortion of the plant tissues while the insect is in the egg stage, and that there is no readily external visible indication of the insects' presence until some weeks after the larvae have hatched.

By the beginning of January, 1937, though the remains of the flowers were visible on the infested globular heads (Plate xx, fig. 2), very definite but minute galls were present.

From general observations over a number of years, it is evident that after the tree finishes flowering and the gall-wasp larvae hatch, the galls continue to increase steadily in size during the remainder of the summer and the following autumn (Plate xx, fig. 3). The galls during this period are bright green and continue to increase in size during the winter, and in the late winter the surfaces of many of the larger galls become tinted with red, but the smaller galls are still bright green (Plate xx, figs. 4 and 5).

The galls showing this red or rosy tint do not increase further in size, and dissection shows them to contain mature or maturing larvae. Thus in *T. trilineata* gall development continues throughout the entire larval period from hatching to pupation. In this respect it differs markedly from *Eurytoma fellis* which causes galls on citrus stems (Noble, 1936). In this case the galls reach their full size while the insect is still in the first larval stage.

On 4th July, 1936, the first mature larvae of *T. trilineata* were found and several were passing to the prepupal stage, and the first pupa was found on 27th July, 1936. At this time galls containing mature larvae and prepupae or pupae were showing the red tint, at least on part of their surfaces.

The surfaces of some of these maturing coloured galls are rough and they are very irregular in shape, while others, particularly the smaller ones, are round, with the surface smooth (Plate xx, figs. 4 and 5). Some of these small round galls were immature at the end of July in 1936, but in others the small size was due to the fact that they contained but one cell.

During the first two larval stages the plant tissues fit closely against the integument of the larvae, but, with the commencement of the third stage, there is a small space between the inner walls of the gall cell and the integument of the larva. This space increases in volume as the larva develops, so that by the time the larva reaches the fifth stage and matures, there is usually quite an appreciable space between the wall of the cell and the host larva. The size of the gall cell or chamber varies greatly, and may be just a little bigger than the mature larva but more commonly is several times the volume of the latter.

During the summer and autumn the galls when cut are found to be very soft and the cells of the nutrient layer surrounding the larva are particularly soft, cut readily and contain a high percentage of liquid.

However, this nutrient layer becomes narrower as larval development progresses and by the time the larva matures it has disappeared and the larva has become surrounded by a narrow, but extremely hard woody layer, which can be cut only with difficulty with a razor. This is in marked contrast to the rest of the gall, which until the adults emerge remains quite soft and fleshy, the cells containing a high percentage of liquid. These outer layers of plant tissue can be readily removed with the finger nail, leaving a number of hard oval cores within which are the mature larvae or pupae.

A number of sections were cut through typical galls of various ages, the general arrangement of the tissues being somewhat the same as that illustrated by Imms (1925, p. 557, after Fockeu) in the gall of *Neuropterus lenticularis*, a cynipid gall wasp occurring in England.

Following the epidermal layer there is an extensive layer of parenchymatous tissue. This consists of numerous rounded thin-walled and large cells. In the maturing galls there follows a layer of smaller cells with very thick walls, and this constitutes the protective layer to which Imms refers. Particularly referring to cynipid galls, he stated that this protective layer is sometimes wanting. In the early stages of gall development in *Tepperella trilineata* the protective tissue cannot be detected as a special layer, but sections of galls in which the larvae are maturing, stained with safranin and Ehrlich's haematoxylin, show a definite protective layer stained a very much deeper red than the adjoining tissues, thus suggesting its woody character, and it is this zone which can be sectioned only with difficulty. Within this protective layer there is a layer of small but soft and highly fluid nutritive cells, the extent of this layer depending upon the stage of development of the larva in the particular cell.

During the course of the investigation all the cells in 731 galls were counted and amounted to 2,307, the average cells per gall being 3·16, the maximum being 11 and the minimum 1. Unilocular galls were quite common, but galls containing 8 or more cells were comparatively rare. The distance between the cells in the galls varied greatly, while the number of cells was not always reflected in the size of the gall. Thus on 15th September, 1937, two galls of equal size were examined, one being found to contain two pupae of *T. trilineata*, while the other contained five.

A typical unilocular gall is spherical or oval in outline, there being a fairly extensive layer of plant tissue surrounding the gall chamber, the latter being usually cylindrical in shape with rounded ends. There is, however, a considerable difference in the width of the plant tissues surrounding the gall chamber in unilocular galls.

In galls of two or three cells their presence is sometimes indicated by definite lobes, the gall being bi- or tri-lobed, but in most cases the general surface of multilocular galls is more or less regular.

Until most of the inhabitants of the galls have emerged the galls remain green in colour, and as adults of various species are emerging from some galls from early in September until the following January, some galls remain green throughout this period.

When most of the cells in a gall have been vacated the gall rapidly shrivels, turns black, and may fall from the tree soon afterwards, the entire twigs bearing these galls drying, turning black and becoming extremely brittle.

Some of these galls fall from the tree before the last adults of *Eurytoma* sp. have emerged, but the adults of this species later emerge from these hard, woody, fallen galls in a normal manner.

A few of the previous season's galls sometimes remain on the tree for many months, and at the time the first adults of *Tepperella trilineata* emerged in September, 1936, there were still a limited number of the vacated 1935 galls on the tree. On 9th November, 1937, there were also fair numbers of the previous year's galls present on this tree.

Insects Associated with Tepperella trilineata in the Galls on Acacia decurrens.

(A). *Hymenopterous species in the galls.*

It has already been pointed out that twelve wasp species emerged from these galls.

The fourth most abundant species was *Coelocyba nigrocincta*, a small yellow and black Chalcidoid which occurred in limited numbers only in these galls. In 1936, of a total of 3,511 adult wasps emerging, only 101 were *C. nigrocincta*. In the spring of 1937, in a total of 573 gall cells examined in one series of dissections, only 23 contained some stage of *C. nigrocincta*.

On a number of occasions in the spring of 1937, pupae of *C. nigrocincta* were removed from gall cells and examination of the cell debris revealed the mandibles of the last-stage larva of *Tepperella trilineata*. On three occasions unilocular galls were dissected in which the pupa or adult of *C. nigrocincta* was present together with the mature larval remains of *T. trilineata*. These galls were in general respects similar to unilocular galls in which *T. trilineata* was present alone.

It is evident that where *C. nigrocincta* is associated with *T. trilineata*, the latter species is able to reach the last larval stage, but the presence of *C. nigrocincta* results eventually in the death of the primary gall former.

Of particular interest is the discovery of the presence of a species of parasitic viviparous nematode within both sexes of the adults of *Coelocyba nigrocincta*, and it is intended to discuss this species further in another paper.

Eurytoma sp., which is the most common of all the species of wasps occurring in the galls, lays its eggs alongside the eggs or larvae of *T. trilineata*. The larvae of the two species occupy the same gall cell and feed phytophagously until the larvae of *Eurytoma* sp. reach the fifth or last stage, when they devour the larvae of *T. trilineata*.

The life-history of *Eurytoma* sp., which is most unusual, has been studied in detail, and will be set out in a separate paper.

Megastigmus sp., second only in abundance to *Eurytoma* sp., is an internal larval parasite of *Tepperella trilineata*, and its life history will be discussed in a separate paper.

In many cells in the galls the larvae of *T. trilineata*, *Megastigmus* sp., and *Eurytoma* sp. were all found to be present. In all such instances the larva of

Eurytoma sp. ultimately devours the larva of *T. trilineata* and any larvae of *Megastigmus* sp. which are within the larvae of *T. trilineata*.

(B). *Insects other than Hymenoptera in the Galls.*

(1) *Lepidopterous larvae.*

Few lepidopterous larvae were found until late winter, but then and in the early spring the occurrence of the larvae of a small moth mining through the galls was quite common.

In the larger galls in which the protective layer was well developed the larvae mined only through the softer parenchymatous tissues and did not then harm the occupants of the cells. However, in cells where the wasp larvae were less mature and the protective layer not so well formed, these moth larvae mined throughout the galls, devouring all but the outer gall layers, and destroying at the same time the various normal occupants of the gall cells.

(2) Myrmacicelus formicarius *Chev.*

During the winter of 1936 larvae of a Curculionid were found occasionally within the galls and in some instances these had devoured the greater part of the internal contents of the galls. Similar larvae later pupated within the mined galls, and on the emergence of the adults it was found to be the ant-like weevil, *Myrmacicelus formicarius* Chev. The first adult emerged on 8th October, 1936, and the last on 9th December, 1936. This species, which was described by Chevrolat (1833), is shining smooth and black and measures one-sixth of an inch in length. It has been figured and recorded by Froggatt (1902), who stated: "This is a queer-looking ant-shaped weevil that crawls about on the trunks and foliage of the wattle and is often taken in the net when sweeping a bush."

So far as the writer knows, the notes in the present paper are the first to throw any light on the life-history of this insect.

Summary.

The detailed life-history of *Tepperella trilineata* Cam., a perilampid wasp causing galling of the flower buds on *Acacia decurrens* var. *pauciglandulosa* in the Sydney district, is described.

The life cycle is annual. The adult wasps emerge from the galls in the early spring, mainly during the second half of September and the first half of October.

Of 1,058 adults which emerged in 1936, 525, or 49·62 per cent., were females and 533, or 50·38 per cent., were males.

There is remarkable sexual dimorphism, the males being dark brown to black, the females being bright yellow and black in colour.

Adults are very short lived, the average length of life of male wasps being 5·48 days and of female wasps 6·34 days.

The average number of eggs within ten females was 534, the maximum being 611 and the minimum 456.

Whether fertilized or not, females commence oviposition on the day of emergence.

The eggs, which prior to oviposition are remarkable bi-lobed structures joined by narrow connecting tubes, are inserted in the minute flower-buds, which are just commencing to appear on the tree at the time the first adult wasps emerge. After oviposition all the protoplasmic contents pass into one body of the egg.

Flower buds in an advanced stage of development are unsuitable for oviposition.

Five larval stages occur, and their detailed external morphology is described.

Each gall represents an aborted globular flower-head. Even though oviposition has occurred, a number of the upper flowers in the globular flower-head bloom, but the lower buds do not open. The galls do not become evident until several months after the larvae have hatched. The galls increase in size slowly throughout the summer and winter and reach their full size at the time the larvae reach maturity. The average number of cells in each gall was 3·16, the maximum being 11 and the minimum 1.

The incubation period is approximately 4 weeks, the larval period being approximately 42 weeks and the pupal period 6 weeks.

Eleven other species of wasps, of which nine were Chalcids, were also bred from the galls.

Limited numbers of a species of Bethylid and also a species of Braconid, which emerged from the galls, are thought to be parasites of lepidopterous larvae which were found commonly mining in the galls.

Of the Chalcids, two species outnumbered all others, viz., *Megastigmus* sp. and *Eurytoma* sp., the latter species outnumbering all others, including the primary gall-former, *T. trilineata*.

Megastigmus sp. is an internal parasite of the larva of *T. trilineata*, and it has an annual life cycle.

The life cycle of *Eurytoma* sp. is also annual.

The egg of *Eurytoma* sp. is laid alongside the egg or larva of *T. trilineata*, and the larvae of the two species live phytophagously in the same cell until the larvae of *Eurytoma* sp. reach the fifth or last stage, when they devour the larvae of *T. trilineata*.

Another species of Chalcid which emerged in small numbers from the galls was *Coelocyba nigrocincta*. It is of particular interest because in both sexes, parasitic viviparous nematodes were found to be present in the abdomen of both pupal and adult wasps. The larvae and pupae of the ant-like weevil, *Myrmacicelus formicarius* Chev. were also present in the galls, and limited numbers of the adults of this weevil emerged during the spring and summer.

Acknowledgement.

The writer wishes to acknowledge his indebtedness to Dr. A. B. Gahan, Senior Entomologist of the United States Bureau of Entomology, for his critical opinion on the species of *Eurytoma* and *Megastigmus* which were submitted to him.

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Galls on *Acacia decurrens* var. *pauciglandulosa* caused by *Tepperella trilineata*.

EXPLANATION OF PLATE XX.

Various stages in the development of galls in the flower buds on *Acacia decurrens* var. *pauciglandulosa* caused by *Tepperella trilineata*.

1.—Young flower buds showing stage at which oviposition occurs. Photographed 15th September, 1936. × 10.

2.—Aborted flower-buds approximately four months after oviposition. Photographed 8th January, 1937, soon after the tree had finished flowering and before there had been any marked gall formation. × 0·8.

3.—Partly developed galls. Photographed 5th May, 1937, approximately eight months after oviposition. × 0·8.

4, 5.—Maturing galls. Photographed 29th July, 1936, approximately ten months after oviposition. × 0·8.

THE ANATOMY OF *HETERODONTUS PORTUSJACKSONI* (MEYER, 1793).

PART I. THE NERVOUS SYSTEM.

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(Twelve Text-figures.)

[Read 28th September, 1938.]

Introduction.

Although some scattered references occur in the literature on this subject, I am aware of no extensive work on the nervous system of *Heterodontus portusjacksoni* (Syn. *H. philippi* of authors) apart from that of de Beer (1924), whose research was carried out on embryological material, the largest embryo described being 70 mm. long. De Beer traced the development of the head with special reference to that of the skull, eye-muscles, nerves and blood vessels. Daniel (1934, p. 231, fig. 210) figures and comments on the brain of a closely allied species, *H.* (= *Gyropleurodes*) *francisci*, but does not give a detailed description of his material; judging mainly from his diagram, however, there are certain differences to be noted in the two species. Of further references on the sense organs in this shark, those of Garman (1888), Goodrich (1930), Allis (1919), and Norris (1929) are the most important and will be commented on in the appropriate section of the paper.

The supply of sharks has enabled me to make several dissections of this system, the largest specimen being more than three feet in length and in a good state of preservation.

The descriptions are grouped under two general headings—1. The Central Nervous System, comprising the brain and spinal cord, and 2. The Peripheral Nervous System, comprising the rest of the nervous system. Wherever it is possible the B.N.A. system of nomenclature has been used.

1. The Central Nervous System.

A. *The Brain.*

The brain is covered by two thin membranes or meninges. The outer one lies close to the wall of the cranial cavity and is very vascular—especially in the region of the anterior fontanelle. The inner membrane lies closely investing the brain and is separated by a considerable space, the perimeningeal space, from the outer one. The two meninges continue into the vertebral canal and stand in the same relation to the spinal cord as they do to the brain. They are connected, one to the other, in various places by fine strands of tissue.

The brain is divisible into three primary vesicles, the fore-, mid- and hind-brain, and to facilitate description the first and third of these two regions are further divided into two parts. The five divisions thus recognized (Fig. 1) from

the anterior to the posterior are the telencephalon (TEL), the diencephalon (DIEN), the mesencephalon (MES), the metencephalon (MET), and the myelencephalon (MYEL).

The telencephalon and diencephalon together comprise the forebrain or prosencephalon. The telencephalon, as the name implies, forms the front part of the brain and is distinctly divided into two by a median anterior groove or sulcus. The separation of the two halves is not as marked in a large *H. portusjacksoni* as Daniel's figure shows for the closely related species *H. francisci*, but a dissection of the brain of a fairly young Port Jackson shark revealed that the furrow was very pronounced and that the pallial eminences were more marked than in larger specimens. Between the two olfactory tracts, on either side of the mid-line, is a prominent bulge caused by the median olfactory nucleus (M.O.N., fig. 2). From the sides of the telencephalon project the two olfactory lobes (OL.L., figs. 1, 2), which are continued forward as the olfactory tracts (OL.T., figs. 1, 2) to the olfactory bulbs (OL.B., fig. 5) which separate into two parts, one medial, the other lateral in position. At the posterior end of the telencephalon, on its dorsal surface, are the pallial eminences which are mound-like eminences and are well seen in a side view of the brain (P.E., fig. 1). In the centre of the dorsal surface of the telencephalon is a small round, cone-like pit, the recessus neuroporicus, which, in a well preserved specimen, is seen to contain blood vessels which enter the brain substance in this region (R.N., fig. 1).

From the ventral surface (fig. 2) the telencephalon is seen to be simple in structure—the two halves are separated by a median sulcus, about mid-way along which arise the terminal nerves (N.T., fig. 2). These are small, thread-like strands which run forward and outward from the sulcus to their ganglia which lie on the ventral surface of the telencephalon. From the ganglia, they join the olfactory tracts and run to the olfactory bulbs. On the floor of the telencephalon is the optic chiasma and the sides of this region form the thickened corpora striata in their lower region.

The diencephalon (DIEN, fig. 1) is only visible on the dorsal surface as a narrow region of the brain, without enlargements, situated just behind the telencephalon and in front of the optic lobes. It is characterized by the fact that on both the dorsal and ventral surfaces there are outgrowths—the pineal stalk and the infundibulum respectively. The pineal stalk (P.S., fig. 1) arises from the middle of the roof of the third ventricle, i.e., the cavity of the diencephalon. It is a long, thin strand of nervous tissue which runs dorsally towards the roof of the brain case. Its distal extremity is situated just behind the anterior fontanelle and is enlarged slightly to form the pineal body (P.B., fig. 1). The third ventricle can be seen when the telencephalon is pressed forward with the flat handle of a scalpel. There is a triangular opening leading into the cavity which lies below and which is roofed over by a thin membrane, plentifully supplied with blood vessels, called the anterior chorioid plexus. On the ventral surface of the diencephalon are the following outgrowths, the infundibulum and the two rounded lobi inferiores (INF.L., figs. 1, 2). On either side, also, is a balloon-like vascular sac, an outpushing of the infundibulum, the saccus vasculosus (S.VASC., fig. 2). The infundibulum meets and fuses with the hypophysis to form the pituitary gland.

The Pituitary Gland.

Though not composed of nervous tissue, the structure of the pituitary gland is included in this section of the paper because of its close association with the brain, to which it is connected through the infundibulum.

It depends from the floor of the diencephalon, and consists of three main portions: an anterior lobe which extends forward between the two lobi inferiores (ANT.L., figs. 1, 2), a very large ventral lobe (V.L., figs. 1, 2) which is attached dorsally to the anterior lobe by the neuro-intermediate part and extends downward to the floor of the braincase. The ventral lobe is strongly attached by tissues to the floor of the braincase and is hard to dissect out. A method which gave good results was to open the braincase and pour in about 10 c.c. of Bouin's fluid and allow the tissues to fix for fifteen minutes. Hardened in this way the pituitary could be removed easily in the whole state.

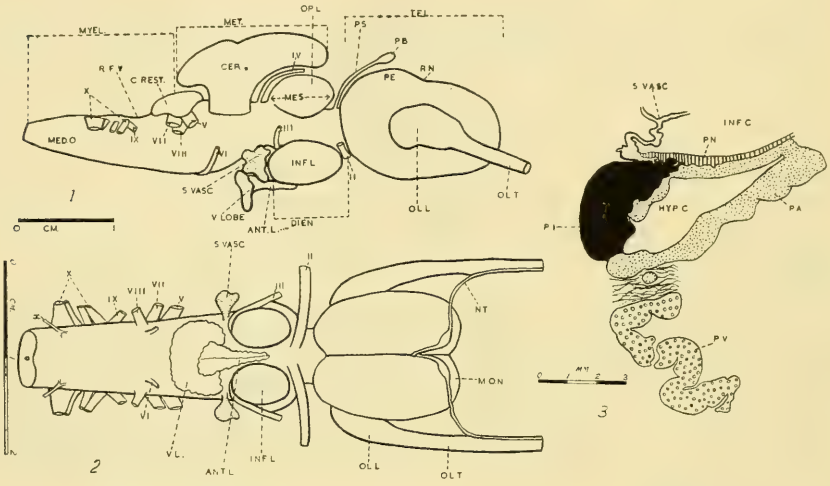

Fig. 1.—Side view of the brain of *Heterodontus portusjacksoni.*

ANT. L., Anterior lobe of pituitary; C. REST., Restiform body; DIEN., Diencephalon; INF. L., Lobus inferioris; MED. O., Medulla oblongata; MES., Mesencephalon; MET., Metencephalon; MYEL., Myelencephalon; OL. L., Olfactory lobe; OL. T., Olfactory tract; OP. L., Optic lobe; P.B., Pineal body; P.E., Pallial eminence; P.S., Pineal stalk; R.N., Recessus neuroporicus; R.F.V., Roof of IVth Ventricle; S. VASC., Saccus vasculosus; TEL., Telencephalon; V. LOBE, Ventral lobe of pituitary; I-X, Cranial nerves one to ten.

Fig. 2.—Ventral view of brain of *H. portusjacksoni.* (For explanation see legend to figure 1.)

M.O.N., Median olfactory nucleus; N.T., Nervus terminalis; V.L., Ventral lobe of pituitary; X, 1st Occipito-spinal nerve.

Fig. 3.—Longitudinal Section of Pituitary of *H. portusjacksoni.*

HYP. C., Hypophysial cavity; INF. C., Infundibular cavity; P.A., Pars anterior; P.I., Pars intermedia; P.N., Pars nervosa; P.V., Pars ventralis; S. VASC., Saccus vasculosus.

A median section of the pituitary (fig. 3) reveals the following structures: 1, A comparatively large hypophysial cavity (HYP.C., fig. 3), situated in the tissues of the pars anterior (P.A., fig. 3). The hypophysial cavity is larger in the sharks than in the rays according to de Beer (1926), and that of *Heterodontus* is large when compared with other sharks.—2, A small area composed of neuroglia fibres which lies just below the infundibular cavity (INF.C., fig. 3), penetrating the pars intermedia in parts and called the pars nervosa (P.N., fig. 3).—3, A pars ventralis (P.V., fig. 3); and a pars intermedia (P.I., fig. 3). The relative sizes and shapes of these parts are shown in figure 3.

The mesencephalon is hidden in a dorsal view by the forward growth of the cerebellum over the optic lobes. The latter can be seen well in a side view, however (OP.L., fig. 1) as paired, rounded outpushings of the roof of the mid-brain. The right and left optic lobes are separated from one another by a deep dorsal furrow. The cavity of the optic lobe, the optocoele, is of moderate size in *Heterodontus*.

The mid-brain is scarcely visible on the ventral surface of the brain. The sides of the mesencephalon are greatly thickened, leaving only a narrow aqueductus cerebri or aqueduct of the mid-brain, between the third and fourth ventricles, and these thickenings constitute the lateral fibre tracts. The third cranial nerve leaves the brain from the floor (III, fig. 1) and the fourth (IV, fig. 1) from the roof of the mesencephalon. The second or optic nerves leave the brain on the ventral surface of the diencephalon. Their fibres may be traced in the brain to the region of the optic lobes.

The rhombencephalon or hind-brain comprises two distinct regions, the metencephalon or cerebellum and the myelencephalon or medulla oblongata. The cerebellum (CER., fig. 1) is a dorsal, somewhat mushroom-shaped outgrowth arising from the roof of the hind-brain, extending forward over the mesencephalon and backward over the rest of the hind-brain which, like the mid-brain, is completely hidden from view. Dorsally the cerebellum is divided into right and left halves by a longitudinal furrow, while occasionally there is also present a less well-marked, transverse furrow at right angles to it. The cavity of the cerebellum is continuous with that of the medulla but is so small as to be almost obliterated.

The myelencephalon (MED.O., fig. 1) consists of those parts of the hind-brain posterior to the metencephalon or the cerebellum. Posteriorly, the myelencephalon merges insensibly into the spinal cord. Underlying the back of the cerebellum on the dorsal surface of the medulla are the restiform bodies (C.REST., fig. 1), raised, rounded thickenings of the roof in this part of the hind-brain. The cavity of the myelencephalon, the fourth ventricle, is covered over by a very thin roof which is plentifully supplied with blood vessels (R.F.V., fig. 1).

All the cranial nerves, back of the fourth, originate from the medulla oblongata.

B. *Spinal Cord.*

The spinal cord—the remainder of the central nervous system—extends from the medulla oblongata into the tail and reaches almost to its tip.

There are no marked dorsal and ventral grooves, and the shape in transverse section is that of an oval, slightly flattened on the ventral surface. The central canal (N, fig. 4) is circular in outline and is situated at approximately the centre of the grey matter. The shape of the grey matter is shown in section in figure 4. The dorsal rami (D.H., fig. 4) are not distinct as two arms, but merge together forming one dorsal mass. The ventral rami (V.H., fig. 4), on the other hand, are quite widely separated and there is a further, small, median ventral mass of grey matter in the mid-line between them (M.V.M., fig. 4).

2. The Peripheral Nervous System.

The remainder of the nervous system will be described under the headings of the Cranial and Spinal Nerves, the Sympathetic Nervous System and the Special Sense Organs.

A. *The Cranial Nerves.*

These nerves in *Heterodontus* are somewhat similar in origin and distribution to the usual elasmobranch type and differ only in small details due to the fact that

the close approximation of the upper jaw cartilage to the skull and the consequent change in some of the muscle origins, has necessitated slight changes in the courses followed by the nerves which supply them. There is no otic branch to the facial nerve, a fact also noted by de Beer (1924*b*).

The first or olfactory nerve is purely sensory and arises as numerous short strands from the mucous membrane of the olfactory organ and passes backward as two short bundles to the olfactory bulb. According to de Beer (1924*b*) these two divisions of the olfactory nerve—the medial and lateral divisions—do not coincide with the two divisions of the olfactory sac. Fine nerve strands from the medial olfactory nerve bundle pass to the lateral part of the olfactory sac and vice versa. The olfactory bulbs are joined to the olfactory lobes of the brain by long, comparatively thick olfactory tracts (OL.T., figs. 1, 2, 5).

Easily seen on the ventral surface of a well-preserved brain are the two terminal or accessory nerves (T.N., fig. 2). They emerge from the floor of the telencephalon in the mid-line as two slender threads, the left one slightly in advance of the right. Each nerve runs outwards a short distance to a single, small ganglion, which lies on the ventral surface of the fore-brain towards its anterior end. De Beer (1924*b*) describes the development of the terminal nerve in this shark and in the last stage, namely 70 mm., which he figures, this nerve lies on the dorso-anterior surface of the fore-brain. In the adult it is, in all the cases I examined, on the ventral surface of the brain and its ganglion has left its position between the two divisions of the olfactory nerve (as described by de Beer in the 70 mm. stage) and now lies on the ventral surface. The adult condition is thus uniform with that of *Squalus* and *Amia*.

The optic nerve (II, figs. 1, 2, 5) originates in the retinal layer of the eye and is purely sensory in function. The fibres gather together and form a thick, round trunk, which passes through the sclerotic layer of the eyeball and runs across the orbit to pierce the wall of the braincase by the optic foramen. It forms a chiasma with its fellow of the opposite side and enters the diencephalon through its floor. The crossing of the nerves takes place just after they have entered the body of the diencephalon and is not visible externally.

The oculomotor nerve (III, fig. 1) emerges from the ventral surface of the mid-brain just behind the inferior lobe and runs dorsally, perforating the side-wall of the cranium above the mid-line of the orbit. On entering the orbit, the nerve splits into three branches. The most anterior branch follows a short course to the internal rectus muscle on which it breaks up into a number of small branches. The middle branch runs over the base of the internal rectus muscle and then divides into two branches which supply the superior rectus muscle. The remaining branch is the largest and supplies the inferior oblique and inferior rectus muscles. It runs first of all posteriorly, over the internal and superior rectus muscles, then passing under the external rectus and beneath the inferior rectus, to which it gives off a branch, it proceeds to the inferior oblique, which it also innervates. This deep branch gives off a fine twig which runs to the ciliary ganglion.

The fourth or trochlear nerve (IV, figs. 1, 5) arises from the dorsal surface of the mid-brain, just behind the optic lobes. It is a fine nerve which runs dorsally in the cranial cavity and perforates the cranial wall high up, in front of the optic foramen. It supplies the fibres of the superior oblique muscle.

The fifth or trigeminal and seventh or facial nerves arise close together from the side of the medulla oblongata, but the roots of the former complex are slightly anterior and below those of the facial nerve (V and VII, fig. 6).

The branches of the fifth nerve pierce the side-wall of the cranium through the orbital fissure, through which also passes the abducens or sixth nerve and also the superficial ophthalmic branch of the seventh nerve (R.O.S.VII, fig. 6). The relationships of the fifth and seventh nerves are shown in figure 6 and do not differ much from those pictured by de Beer (1924*b*) except that the two nerves and their ganglia are more closely associated in the adult than in the embryo.

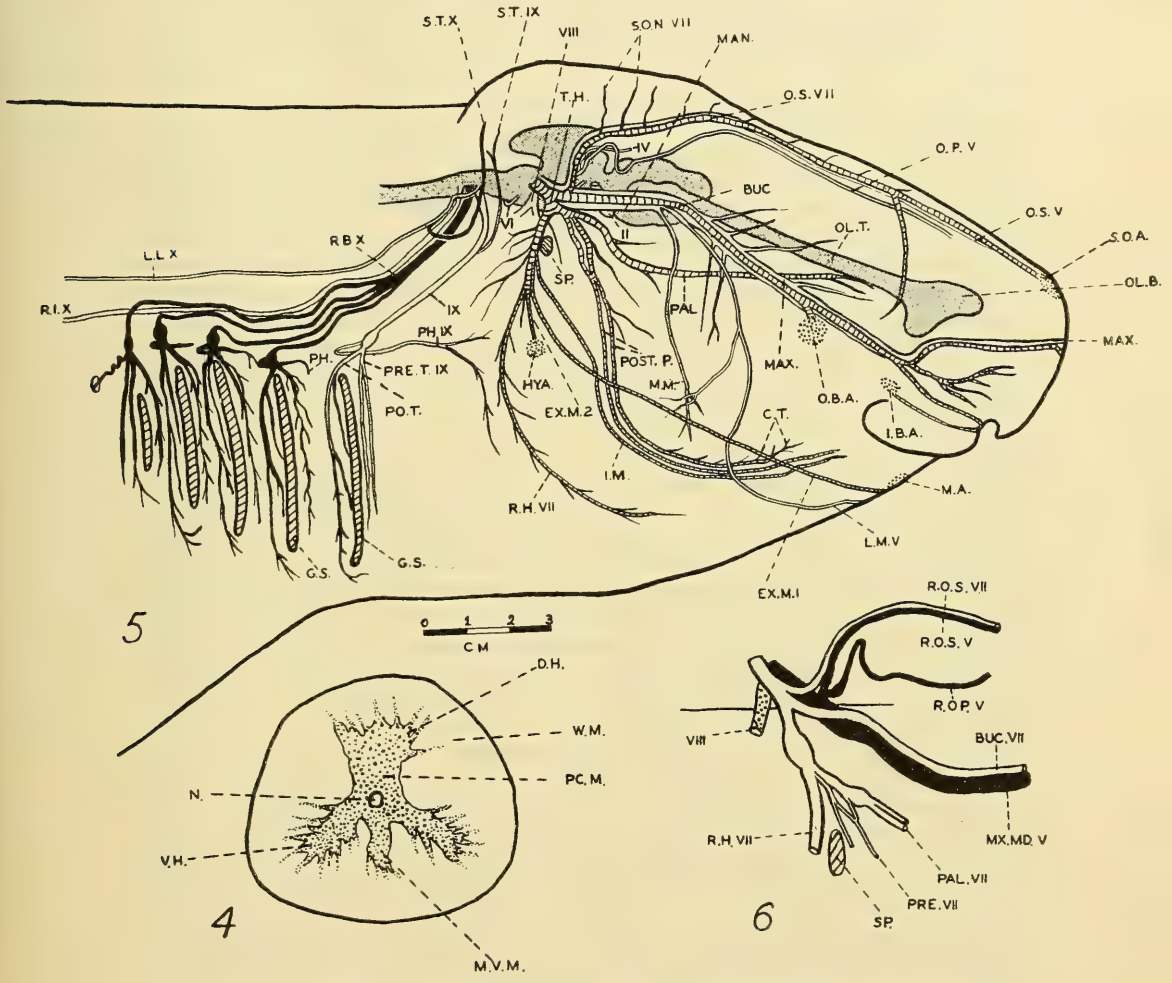

Fig. 4.—T.S. Spinal Cord of *H. portusjacksoni*.

D.H., Dorsal horn of grey matter; M.V.M., Median ventral mass of grey matter; N., Central canal; PC. M., Paracentral mass; V.H., Ventral horn of grey matter; W.M., White matter.

Fig. 5.—A Projection of the Sagittal Plane of the Cranial Nerves of *H. portusjacksoni*. The outlines of the brain are schematic.

BUC., Buccal branch of VII; C.T., Fine branches of palatine to oral epithelium; EX. M.1 & 2, External mandibular branches of VIIth nerve; G.S., Gill slit; HY.A., Hyoid ampullae; I.B.A., Inner buccal group of ampullae; I.M., Internal mandibular VII; L.L.X., Lateral line element of Xth nerve; L.M.V., Lateral branch of mandibular nerve; M.A.,

The main branches of the fifth nerve are four in number, namely, the superficial ophthalmic, the deep ophthalmic, the maxillary and the mandibular nerves.

1.—The superficial ophthalmic which is a mixed nerve (o.s. v, fig. 5) runs dorsally from its ganglion along with the nerve fibres of the superficial ophthalmic branch of the facial nerve. The two nerves continue forward through the orbit, lying close to and high up next to the outer side of the cranial wall. At the anterior end of the orbit these nerves pass through a tunnel in the cartilage and emerge on the dorsal surface of the skull and then run for some distance just beneath the skin towards the snout, giving off branches to the skin along their course.

2.—The deep ophthalmic (o.p.v., fig. 5), after leaving its ganglion, passes forward in the orbit as a fairly fine nerve. From the orbital fissure (for names of foramina in the skull see Daniel, J. F., 1934) it runs dorsally over the external rectus muscle, under the superior rectus muscle, and then turning forwards it runs near the back of the eyeball to which it gives off four small twigs. It passes between the two oblique muscles to the anterior wall of the orbit where it passes through a tunnel in the cartilage of the pre-orbital process just below the superficial ophthalmic, and emerges on the dorsal surface along with the latter. It supplies the tissues in this area, as well as the skin of the cheek region.

In the orbit, near the origin of the external rectus muscle, this nerve gives off a tiny branch of non-medullated fibres, the ciliary branch, which runs to the ciliary ganglion, where it is joined by a small branch from the deep branch of the oculomotor nerve. The ciliary ganglion gives off a branch which enters the eyeball and supplies the ciliary muscles.

3.—The maxillary nerve (max., fig. 5) arises from the Gasserian ganglion and passes in close association with the mandibular branch and the buccal branch of vii across the floor of the orbit to its antero-ventral corner. From here it runs with the buccal branch of vii forward across the cheek to the base of the olfactory capsule, but always lying deeper than the buccal branch. The nerve turns sharply medially and runs between the muscles and the back of the olfactory capsule till it reaches the outer side of the pterygo-quadrate cartilage. Here it turns forward and runs beside the upper jaw towards its symphysis with its fellow from the opposite side, giving off, throughout its course, branches to the tissue and muscles. These branches are represented in figure 5.

Mandibular ampullae; man., Mandibular branch of Vth; max., Maxillary branch of V; m.m., Medial branch of Mandibular V; o.b.a., Outer buccal group of ampullae; ol. b., Olfactory bulb; ol. t., Olfactory tract; op.v, Deep ophthalmic of Vth nerve; os.v, Superficial ophthalmic branch of Vth nerve; os.vii, Superficial ophthalmic branch of VIIth nerve; pal., Palatine branch of VII; ph., Pharyngeal branch of Xth nerve; ph.ix, Pharyngeal branch of IXth nerve; post. p., Posterior branch of palatine VII; po.t., Post-trematic branch of IXth nerve; pre.t.ix, Pre-trematic branch of IXth nerve; r.b.x, Branchial division of Xth nerve; r.h.vii, Hyoid branch of VII; r.i.ix, Visceral branch of vagus; s.o.a., Supra-orbital group of ampullae; s.o.n.vii, Nerves to sense organs of supra-orbital canal; sp., Spiracle; st.ix & x, Supra-temporal branches of the IXth and Xth nerves; t.h., Truncus Hyoideus; i-x, Cranial nerves 1-10.

Fig. 6.—Diagram of the Relations of the Trigeminal, Facial and Auditory nerves in *H. portusjacksoni*.

The Trigeminal nerve is black, the Facial white, and the Auditory is stippled.

buc.vii, Buccal branch of the VIIth nerve; mx.md.v, Maxillary and Mandibular branches of the Vth nerve; pal.vii, Palatine branch of the VIIth; pre.vii, Pretrematic branch of the VIIth nerve; r.h.vii, Hyoid branch of the VIIth nerve; r.o.p.v, Deep ophthalmic branch of the Vth nerve; r.o.s.v & vii, Superficial ophthalmic branches of the Vth and VIIth nerves; sp., Spiracle.

4.—The mandibular nerve (MAN., fig. 5) arises from the Gasserian ganglion and runs in close association with the maxillary and buccal branches to the antero-ventral border of the orbit where it curves sharply towards the ventral surface and divides into two branches. The medial of these two branches passes directly towards the ventral surface and runs just lateral to the pterygo-quadrate cartilage, under the muscles (M.M., fig. 5). It gives off many small branches which supply the adductor mandibulae muscle fibres.

The lateral branch of the mandibular curves over the main mass of the adductor and, passing between the muscles, runs to the ventral surface to innervate the skin of the lower jaw region (L.M.V., fig. 5) as well as the first superficial ventral constrictor muscle. A branch passes into the levator labialis inferioris muscle. Branches are also supplied to the levator maxillae and the first superficial dorsal constrictor muscle. The branches are small and are given off from the mandibular in the orbit but are not shown in the figures.

The sixth or abducens nerve (VI, figs. 1, 2, 5) arises from the myelencephalon almost in the mid-ventral line, just behind the region where the fifth and seventh nerves arise. The sixth nerve then runs under the fifth and seventh complex and passes through the cranial wall along with the fifth nerve to the external rectus muscle which it supplies.

The seventh or facial nerve emerges from the cranium through the hyomandibular nerve foramen, except for the superficial ophthalmic branch which, as already described, enters the orbit through the orbital fissure. Its relationships with the fifth nerve are shown in figure 6. This nerve is made up of two groups of fibres, one of which innervates the sense organs of the skin and the other comprises the facial nerve proper. The following branches supply sense organs: (1) the superficial ophthalmic, (2) the buccal and (3) the external mandibular.

The superficial ophthalmic branch (O.S.VII, fig. 5) arises from its ganglion and, emerging from the cranium through the orbital fissure, runs with the superficial ophthalmic branch of the fifth nerve over the dorsal surface of the muscles of the orbit to its anterior border, where it passes into a tunnel in the cartilage in the pre-orbital process, at a higher level than that of the deep ophthalmic V nerve. Throughout its course in the orbit, fine, thread-like branches (S.O.N., fig. 5) are given off and these pass through foramina in the cartilage roofing the orbit, to the sense organs of the supra-orbital sensory canal. Emerging on the roof of the cranium from the tunnel of cartilage in front of the orbit, the nerve runs forward towards the snout, lying under the supra-orbital canal which it supplies. It also innervates a group of ampullae, the supra-orbital group (S.O.A., figs. 5, 10, 11) situated under the skin on the tip of the snout. About half-way between the supra-orbital ridge and the snout, a branch is given off from the nerve; this runs forward and downward to supply the sense organs of the region of the sensory canal which curves round the side of the nasal capsule.

The buccal branch (BUC., fig. 5) runs across the floor of the orbit with the maxillary and mandibular branches of the fifth nerve. *Heterodontus* thus agrees with *Mustelus* (Allis, 1901) in that those three branches make up the truncus infra-orbitalis, whereas in *Squalus acanthias* (Norris and Hughes, 1920) only the buccal and maxillary branches do so. From the antero-ventral border of the orbit the buccal runs forward and downward across the cheek region and consists at this point of a number of fairly large bundles of fibres rather than one large trunk. Situated about midway between the orbit and the snout, lying just under the skin, is an encapsulated bunch of ampullae (O.B.A.) to which the buccal sends a large branch. On the distal side of these ampullae the buccal is considerably smaller

and continues forward to the base of the nasal capsule, along with the maxillary nerve, and in this region curves inwards behind the olfactory capsule towards the pterygo-quadrate cartilage. It separates into two groups of fibres, one of which runs between the nasal capsule and the upper jaw and supplies the anterior extremity of the infra-orbital sensory canal, while the other group of fibres supplies the infra-orbital canal in the region of the superior oral fold, i.e., on the latero-ventral aspect of the olfactory capsule and also the inner buccal group of ampullae. In its passage across the orbit the buccal gives off small twiglets which innervate the sense organs of the infra-orbital canal. These branches are not shown in figure 5, but they are quite numerous.

According to de Beer (1924*b*), and from my own observations, there is no otic branch in *H. portusjacksoni*. *Heterodontus* is thus different from *Squalus*. Innervation of the spiracular sense organ is brought about by a fine branch of the buccal, given off in the posterior region of the orbit.

The hyoid trunk of the seventh nerve (T.H., fig. 5) is composed of a number of types of fibres, which may be classified as: (1) branches innervating the sensory canals and ampullae (e.g., external mandibular), which are therefore comparable with other nerves supplying the acoustico-lateral system; (2) visceral sensory fibres represented by the palatine and internal mandibular branch, and (3) visceral motor fibres which supply certain of the head muscles.

The hyomandibular trunk leaves the cranium and enters the orbit through a large foramen, placed low down and towards the back of the orbit. From here the nerve trunk runs outward and slightly backward, lying just underneath the oto-hyoid ligament for some distance. Numerous, fine, twig-like branches are given off from the main nerve trunk and supply the muscles in this region with motor fibres. The various branches and their destinations will now be described under the classification given immediately above, which is the most convenient.

1.—The external mandibular (EX. M. 1 and 2, fig. 5) supplies only sense organs of the skin and in *Heterodontus* has two main divisions. The nerve runs from the main truncus hyomandibularis outward behind the spiracle. About midway between the origin and insertion of the pterygo-quadrate levator muscle the two divisions separate, the one runs forward across the cheek just beneath the skin (EX. M. 1, fig. 5) and the more posterior branch, which is very short, continues to follow the line between the hyoid and mandibular arches (EX. M. 2, fig. 5). The former branch innervates the hyomandibular and mandibular sensory canals and also a knot of ampullae on the lower jaw situated just behind the inferior oral fold. The more posterior branch supplies the hyoidean group of ampullae which is situated outside the hyoid arch about half-way up the side of the head. This branch appears thus to terminate abruptly in this region.

2.—Visceral sensory fibres are represented by the palatine and internal mandibular branches of this nerve.

The palatine branch (PAL., fig. 5) of the truncus hyoideus is a very large branch leaving the main branch near the cranial wall. It is best displayed in *H. portusjacksoni* by disarticulating the pterygo-quadrate from the cranium and pulling the upper jaw slightly away from the latter. The various branches of the palatine can then be traced through the tissues lining the buccal cavity.

The palatine arises from the geniculate ganglion and runs forward and downward in front of the spiracle. It divides into two main parts, one of which (PAL., fig. 5), after passing round to the ventral surface of the cranium, runs forward medial to the ramus of the upper jaw, giving off branches to the dorsal oral epithelium. The posterior branch of the palatine immediately divides into two

(POST. P., fig. 5) and these two nerves run over the antero-dorsal wall of the spiracle, to the tissues of which a small pretrematic branch is supplied. The nerves then run down the medial surface of the pterygo-quadrate cartilage to the lower jaw where they curve forward and run, just below the teeth, towards the symphysis of the lower jaw cartilages. Throughout their course they give off small twigs (C.T., fig. 5) which supply the oral epithelium of the side walls and spiracular region and the lower jaw.

The internal mandibular branch (I.M., fig. 5) arises from the hyoid trunk ventral to the posterior palatine nerves. It runs downward towards the lower jaw, behind the spiracle and medial to the pterygo-quadrate cartilage. It lies almost parallel to the posterior palatines. On the floor of the mouth it runs forward between the basihyal and mandibular cartilages, terminating between the symphysis of the lower jaw cartilages.

3.—The hyoid branch (R.H.VII, fig. 5) constitutes the viscero-motor fibres of the hyoid trunk. Its fibres run in the hyoid trunk, closely associated with those of the external mandibular, behind the spiracle giving off, as already described, fine nerves to the muscles in this region. The nerve continues to follow the line of the hyoid arch on to the ventral surface where it runs forward. It supplies, in passing, the second superficial dorsal constrictor and both superficial ventral constrictors 1 and 2. In the orbit a small branch runs to the first superficial dorsal constrictor. This branch is not represented in figure 5.

The acoustic nerve (VIII, figs. 1, 2, 5) arises from the brain along with the hyomandibular branch of the seventh. The two nerves are closely bound up together and pass out from the brain through the cartilage of the base of the otic capsule. A very short distance from its ganglion which lies beneath the hyomandibular, the eighth nerve divides into two branches. The anterior one divides into two branches which supply the ampullae of the anterior and the horizontal semicircular canals. The other branch passes backward and outward, subdividing into a number of small branches which supply the ampullae of the posterior semicircular canal and the remaining regions of the ear.

The ninth or glossopharyngeal nerve (IX, figs. 1, 2, 5) arises from the brain posterior to the sixth nerve, from a slightly more lateral position and runs through the cartilage of the floor of the otic capsule where it forms a ganglion above the first gill-slit. Before it enters the ganglion, the ninth nerve gives off a small dorsal, supra-temporal branch (ST.IX, fig. 5) which innervates the anterior (sometimes called the temporal or post-orbital) part of the lateral line canal. There is given off from this supra-temporal a small twig which runs backward, but its destination could not be determined. It probably supplies pit organs which I have not been able to locate. These two branches constitute the dorsal ramus of the ninth nerve. Three branches arise from the ganglion and of these the most anterior, the pre-trematic (PRE.T.IX, fig. 5) runs, as two or three branches, side by side, to the anterior side of the first gill-pouch and innervates the hyoidean hemibranch. It lies beneath the mucous membrane of the gill filament. From the posterior side of the pre-trematic a small nerve is given off just ventral to the ganglion. This is the pharyngeal branch (PH.IX, fig. 5) and soon curls forward and supplies the integument on the roof of the mouth. This pharyngeal nerve gives rise to a branch which runs down the side of the pharynx internal to the hyoid arch under the mucous membrane and, I think, corresponds to the internal pretrematic branch described by Daniel (1934) for *Heptanchus*. A third branch arises from the ganglion, the post-trematic (P.O.T., fig. 5) which immediately divides into two main branches, one of which lies in a slightly more anterior position on

the gill arch and gives off branches to the internal side of the arch. Both branches of the post-trematic run in the anterior hemibranch of the first holobranch. The longer of the two post-trematics continues on to the ventral surface of the gill arch, giving off twigs to the branchial muscles on the way, and finally continues on to the floor of the pharynx which it innervates.

The ninth nerve is a mixed nerve, containing both motor and sensory fibres. The posterior ramus of the post-trematic is mixed and supplies motor fibres to the muscles in this region and sensory fibres to the mucous membrane. The anterior ramus of the post-trematic is sensory, as is also the pharyngeal one.

The vagus (x, figs. 1, 2, 5) arises from the medulla oblongata by several large roots which on closer examination prove to be made up of several smaller nerves. These smaller roots are seven in number, the most anterior lying just above the root of the ninth nerve and the remainder along a line from this point to another point on the dorsal surface, just behind and beside the roof of the fourth ventricle (fig. 1). All the nerves from these roots pass together through a foramen in the cranial wall which lies at a higher level on the skull than that of the ninth nerve and is slightly posterior in position to the latter. On the outer wall of the cranium the vagus appears as three large bundles of nerves, closely bound together. From this bunch of nerves run three groups of fibres: (1) the ramus lateralis (L.LX., fig. 5) which supplies the lateral line sensory canal; (2) the branchial divisions (R.B.X, fig. 5) of the nerve which supply the gill region other than that supplied by the ninth nerve; and (3) the third or visceral ramus which runs to the gut (R.I.X., fig. 5). The most anterior group of fibres to leave the brain passes into the ramus lateralis. This nerve runs towards the tail, between the dorsal and the ventral longitudinal muscle bundles and just beneath the lateral line. It extends almost to the tip of the tail. Even in the foramen in the cranial wall these fibres are distinct from those of the other groups. A small branch is given off in this foramen which innervates part of the supra-temporal region of the sensory canal (S.T.X., fig. 5). Its course is through the posterior cartilage of the otic capsule. Throughout its length the lateralis gives off fibres to the sensory organs of the lateral line. From the cranial wall the lateralis runs outward and backward, touching the wall of the anterior cardinal sinus, and then runs between the dorsal and ventro-lateral muscle bundles.

The next group of fibres forms the branchial part of the vagus, the biggest division of the nerve. The branchial nerves are four in number and lie in the floor of the anterior cardinal sinus and their ganglia lie one above each of the last four gill-slits. From each ganglion nerves run to the gill tissues, similar in distribution and number to those of the ninth nerve, except for the fact that the pre-trematic branch is single. There is, therefore, a pre-trematic branch which runs to the anterior hemibranch of the second gill-pouch where it branches immediately behind the cartilaginous branchial rays and innervates this region. The second branch is the post-trematic which immediately divides into two and runs to the anterior hemibranch of the second gill (i.e., the posterior hemibranch of the second gill-pouch). Each branch runs in the gill tissues in the same manner as the corresponding branch of the ninth nerve. The third branch, the pharyngeal, differs from that of the ninth nerve in that, instead of running forward at once on to the roof of the pharynx, it first runs backward over the top of the inter-arcuales muscles and then curves forward and inward on to the pharyngeal roof. (The above remarks apply to the distribution of the nerves of the second gill-pouch, which is typical.)

There is a slight difference in the last or fourth branchial. A slender nerve is given off from the ganglion which runs through the foramen of the fifth and

rudimentary sixth epi-branchial cartilage and so to the side wall of the oesophagus; here it subdivides into numerous tiny branches which run forward on the ventral wall of the oesophagus to the sinus venosus of the heart. These fibres, therefore, represent the cardiac portion of the vagus, the fibres having separated from the visceral branch in the region of the anterior cardinal sinus and running from there with the fourth branchial branch for a short distance.

The Visceral Branch of the Vagus.

The third group of fibres of the vagus, the ramus intestinalis, runs closely associated with the fourth branchial branch to the region of the third holobranch. Here it separates from the branchial and continues to run backward and then turns slightly towards the midline. It enters the body cavity and breaks up into three large branches which later subdivide still further and run to the oesophagus, stomach and other viscera.

B. *Occipito-Spinal Nerves.*

In *Heterodontus* there are three occipito-spinal nerves designated as nerves *x*, *y* and *z*, from anterior to posterior respectively (fig. 7, *x*, *y* and *z*).

The rootlets of the nerve *y* arise from the ventral surface of the medulla at the level of the more posterior roots of the vagus nerve and are similar in appearance to the sixth cranial nerve. The small nerve, *x*, is very tiny and therefore difficult to dissect, but it occurs a short distance in front of *y* and has a similar origin from the ventral surface of the medulla.

The nerve *y* runs under the vagus through the cartilage where it turns backward to join the nerve *z*, and these two run together to join the hypobranchial nerve.

The nerve *z*, in *Heterodontus*, does not appear to possess a dorsal root as in some other Elasmobranchs, and is like *y* in origin and size. It joins *y*, as mentioned above, and runs with the hypobranchial nerve.

C. *Spinal Nerves.*

Each spinal nerve is a mixed nerve and has a single, dorsal, sensory root and a ventral, motor root arising from the spinal cord. The ventral root arises from the cells of the ventral horn of the grey matter, while the dorsal root extends from the dorsal horn of the grey matter to the dorsal root ganglion which lies in the cavity of the spinal column, and from here nerve fibres pass outward through the wall of the spinal column to join those of the ventral root. The ventral root pierces the basidorsal cartilage and its corresponding dorsal root pierces the succeeding interdorsal cartilage; the ventral root thus lies in front of its dorsal root. The mixed nerve, which is formed by these two nerve-elements, runs outward to supply the tissues of the corresponding segment of the body. In the region of the dorsal and ventral unpaired fins, the spinal nerves send branches to their muscles. In the region of the neck and shoulder, the spinal nerves form plexuses, the hypobranchial and pectoral plexuses.

At the level of the 15th spinal nerve, in the region just above the lateral abdominal vein, the terminal twigs of this and succeeding nerves up to the 25th nerve are connected together to form a nervous collector system.

The hypobranchial or cervical plexus in *Heterodontus* is formed by the union of the occipito-spinales nerves *y* and *z*, and the first two spinal nerves. These nerves run closely bound together, nevertheless retaining their individuality, above the branchial region with the branchial branches of the vagus nerve. Behind the vestigial sixth branchial arch (Hawkes, 1906) this plexus turns sharply downward

and, running in front of the pectoral arch, reaches the longitudinal hypobranchial muscles which it innervates by its various branches (HYP. P., fig. 7).

A small twig is given off posteriorly, which joins the third spinal nerve. The third spinal nerve runs close to the fourth one, following a course almost parallel to that of the hypobranchial nerve. It divides into two; one half runs to the hypobranchial region just anterior to the pectoral girdle, whilst the other half runs with the fourth, fifth and sixth spinal nerves through the foramen in the pectoral girdle to the muscles of the pectoral fin (see fig. 7, 3).

The third, fourth, fifth and sixth spinal nerves are not closely bound together, but they represent the pectoral plexus of other sharks since they run together through the pectoral girdle foramen to the muscles of the dorsal side of the fin (BR. P., fig. 7). The fifth and sixth nerves also display a slight degree of fusion, about half-way between the spinal column and the ventral surface. The spinal nerves, as far back as the fifteenth, run to the dorsal side of the pectoral fin. The pelvic fin (and, in the male, the clasper) is supplied by spinal nerves 23 to 37.

D. *Sympathetic Nervous System.*

This system in *Heterodontus* is represented in the head by the ciliary ganglion and nerves. The ciliary ganglion lies in the back of the orbit, low down between the rectus muscles and the eyeball. The nerves running to it have already been described (pages 416, 418). In the trunk there is a small but extensive sympathetic nervous system. The anterior part of this system is so closely associated with the chromophil bodies of the adrenal glands that it is difficult to distinguish between them. The posterior part of the sympathetic nervous system comprises a series of segmentally-arranged ganglia which are not associated with the chromophil bodies and which are not connected with one another in a chain (fig. 8).

The ganglia occur as two longitudinal series, lying one on either side of the dorsal aorta. The anterior ganglion is the largest and represents several fused ganglia. It receives three twigs from the spinal nerves and gives off sympathetic nerves, three in number, which run in the mesentery along with the coeliac axis to the viscera (SY. N., fig. 8).

The posterior ganglia are small and extend back to the posterior region of the kidneys, to which they supply small twigs, as well as giving off branches to the posterior viscera and genital ducts.

E. *Special Senses.*

Under this heading the olfactory organ, organs of taste, the auditory organ, and the neuromast system will be described.

The Olfactory Organs.—The olfactory organs of *Heterodontus portusjacksoni* show an interesting difference from the structure found in a form such as *Heptanchus*. The incurrent nasal aperture is situated on the ventral surface, fairly near the tip of the snout (N.A.P., fig. 10A), while the excurrent opening leads backward on to the roof of the mouth, the angle between the axes of the two canals being about 70°. The opening of the excurrent canal is surrounded by a frill of dermal tissue (F.E.D., fig. 10A) which depends from a somewhat triangular fold of the upper lip (T.F., fig. 10A).

Allis (1919) has described the structures of the nasal organs of a heterodont shark, probably *Gyropleurodes francisci*, and a comparison showed that *Heterodontus portusjacksoni* has nearly similar structures, the differences being minor

ones such as the shape of the openings of the nasal pit and the shape of the secondary upper lip. These differences are best shown by comparing figure 10A of this paper with figure 6, Plate 2, of Allis's paper and with his descriptions on pages 158–164.

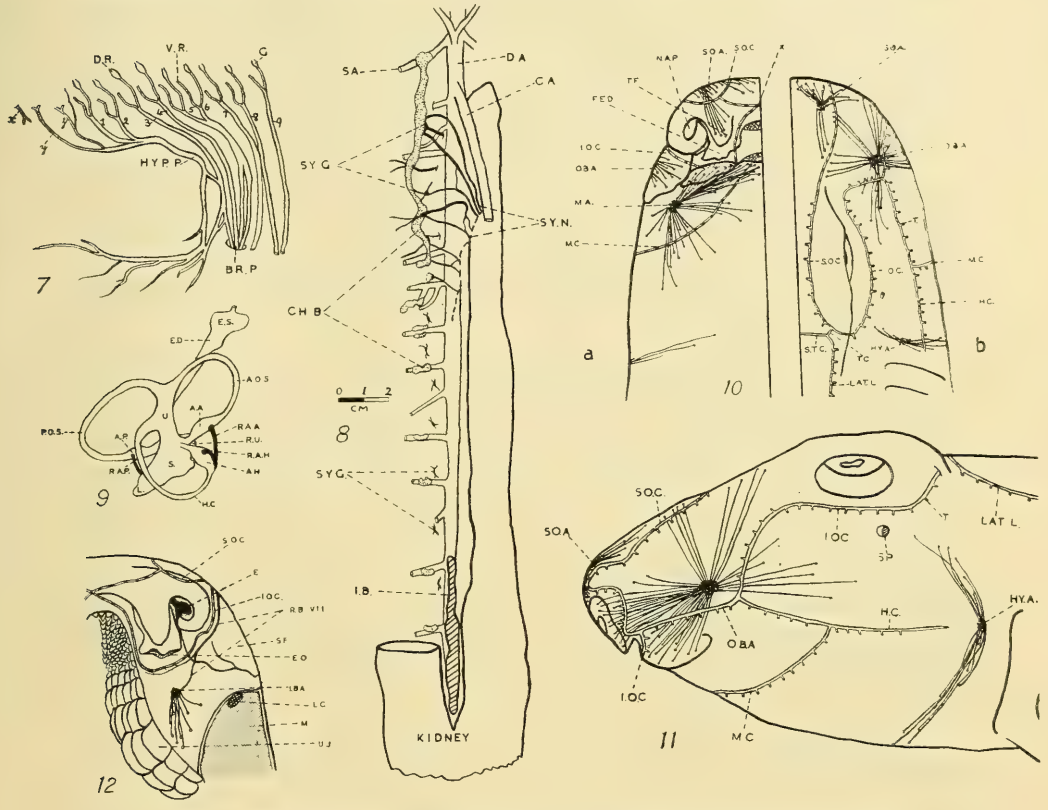

Fig. 7.—Diagram of the Occipito-spinal and First Nine Spinal Nerves. Viewed from Left Side.

BR.P., Brachial plexus; D.R., Dorsal root of spinal nerve; G., Ganglion of dorsal root of spinal nerve; HYP.P., Hypobranchial plexus; V.R., Ventral root of spinal nerve; *x*, *y* and *z*, The occipito-spinal nerves; 1-9, Spinal nerves 1-9.

Fig. 8.—Sympathetic Nervous System, Supra- and Inter-renal Bodies of *H. portusjacksoni* (right kidney removed).

C.A., Coeliac axis; CH.B., Chromaphil bodies (= medulla of adrenals of higher vertebrates); D.A., Dorsal aorta; I.B., Interrenal body (= cortex of adrenals of higher vertebrates); S.A., Sub-clavian artery; SY.G., Sympathetic ganglion; SY.N., Sympathetic nerves.

Fig. 9.—Right ear of *H. portusjacksoni* viewed from the outside.

A.A., Ampulla of anterior oblique semicircular canal; A.H., Ampulla of horizontal semicircular canal; A.P., Ampulla of posterior oblique semicircular canal; A.O.S., Anterior oblique semicircular canal; E.D., Endolymphatic duct; E.S., Endolymphatic sac; H.C., horizontal canal; L., Lagena; P.O.S., Posterior oblique semicircular canal; R.A.A., Branch of VIIIth nerve to ampulla of A.O.S.; R.A.H., Branch of VIIIth nerve to ampulla of H.C.; R.A.P., Branch of VIIIth nerve to ampulla of P.O.S.; R.U., Recessus utriculi; S., Sacculus; U., Utriculus.

MARINE BIOLOGICAL LABORATORY

The nasal cartilage in *H. portusjacksoni* is similar in all respects to that described by Daniel (1915) for *H. francisci* (= *Gyropleurodes francisci*). It does not form a complete ring and is not fused at any point with the nasal capsule, as Gegenbaur (1872) stated, but is merely attached to the latter by tissues.

The incurrent opening of the nasal aperture is pear-shaped with the broad end directed postero-laterally, and appears to be larger than that described by Allis in *G. francisci*. This opening leads into the nasal pit, which is quite large and somewhat reniform in shape. The excurrent canal leads backwards from the medial surface of the "kidney" to the roof of the mouth.

The outer layer of the oral and medial walls of the olfactory capsule is formed of a strong sheet of membraneous tissue, extending from the basi-trabecular cartilages, on the inside, across the floor of the capsule to join the tips of the nasal cartilage and the lateral edge of the nasal capsule. It is only interrupted where the excurrent opening of the nasal pit leads to the roof of the mouth. The median raphe of the folded, Schneiderian membrane lies parallel to the long axis of the incurrent nasal aperture. There are about 35 folds in the membrane on either side of the raphe.

The incurrent canal is separated quite effectually from the excurrent one by two flaps of tissue which overlap but do not fuse, the lateral one projects upward while the medial one hangs downward from the secondary upper lip.

The receptor organs lie in the Schneiderian folds and they send posterior fibres to the olfactory bulb, entering the latter as the true olfactory nerve.

Sensations received by the olfactory bulb are transmitted to the olfactory lobes of the brain by the olfactory tracts (OL.T., fig. 1) which pass back from the nasal capsule through the wide olfactory foramen.

Taste Organs.—There are numerous taste buds in the integument lining the mouth and pharynx where they occur on the roof, floor and sidewalls. They are more numerous towards the posterior part of these regions, especially at the back of the "tongue" process where they are only 3 mm. apart as opposed to 5 mm. at its anterior end. These organs are innervated by the visceral sensory fibres of the seventh and ninth nerves.

Auditory Organ.—The ear in *H. portusjacksoni* is housed in a strong, cartilaginous otic capsule on whose roof is the prominent post-orbital process of the

Fig. 10.—Diagram of Cephalic Canals and Ampullae of Lorenzini in *H. portusjacksoni*. 10A, Ventral view; 10B, Dorsal view.

Ampullae represented by solid black dots, pores by open dots, and tubules by a line. F.E.D., Frill of dermal tissue below ex-current opening of nasal organ; H.C., Hyomandibular sensory canal; HY.A., Hyoidean group of ampullae; I.O.C., Infra-orbital canal; LAT.L., Lateral line canal; M.A., Mandibular group of ampullae; M.C., Mandibular sensory canal; N.A.P., Incurrent nasal aperture; O.B.A., Outer buccal group of ampullae; S.O.A., Supra-orbital ampullae; S.O.C., Supra-orbital canal; S.T.C., Supra-temporal canal; T., Tubule of sensory canal; T.C., Temporal canal; T.F., Triangular fold of upper lip; *x*, Point of junction of S.O.C. and I.O.C. in middle of upper lip.

Fig. 11.—Diagram of the Side View of Head showing Sensory Canals and Ampullae of Lorenzini. (For explanation see Figure 10.) SP., Spiracle.

Fig. 12.—Diagram of Roof of Mouth. Lower Jaw removed to show the Sensory Canals and Ampullae.

E., In-current opening of nasal organ; E.O., Ex-current opening of nasal organ; I.B.A., Inner buccal group of ampullae; I.O.C., Infra-orbital canal; L.C., Labial cartilage (cut); R.B.VII, Branch of buccal nerve VII; S.F., Superior oral fold; S.O.C., Supra-orbital canal; U.J., Upper jaw.

cranium. There are no external traces to indicate the positions of the various canals of the auditory organ. The ear consists of three semicircular canals with their ampullae and a saccular and an utricular region.

The anterior oblique semicircular canal (A.O.S., fig. 9) and the horizontal semicircular canal (H.C., fig. 9) have their ampullae at their lower and anterior ends, quite close to one another, and leading into the utriculus (A.A. & A.H., fig. 9). Near the junction of these two canals with the utriculus (U., fig. 9) is an opening from the latter into the sacculus, the recessus utriculi (R.U., fig. 9). The ampulla of the posterior oblique semicircular canal (P.O.S., fig. 9) does not join directly on to the utriculus. This ampulla is ventral in position and connects with the utriculus by a short canal (A.P., fig. 9).

The sacculus is not very large, and, from its posterior floor-region, a small, tongue-like sac, the lagena (L., fig. 9) projects obliquely outward and backward. The sacculus is continued dorsally on its medial side, into the endolymphatic duct. This duct is considerably larger where it opens to the surface of the head and forms an endolymphatic sac (E.S., fig. 9).

The various regions of the ear are all innervated by the eighth nerve which branches into two on leaving the brain case, each of these in turn giving rise to further branches. The anterior nerve and its twigs supply the ampullae of the A.O.S. and H.C. and is the smaller of the two; the larger, posterior branch supplies the ampulla of the P.O.S., the saccular region and the utricular region and also gives off a small branch to the lagena. The innervation is thus similar to that pictured by Daniel (1934, fig. 236 D, page 270) for *Heterodontus* (= *Gyropleurodes*) *francisci*, and the only differences lie in the size and shape of the sacculus and the endolymphatic sac.

Sensory Canal System.—The sensory canal system of this shark has been described and figured by Garman (1888) and that of a closely related species, probably *Heterodontus* (= *Gyropleurodes*) *francisci*, has been figured by Norris (1929), but since I cannot agree with the nomenclature used by the former and find a short temporal canal not shown by Norris I am including my own drawings and descriptions.

The lateral line canal extends from almost the tip of the caudal fin to the head region where it joins the supra-temporal canal (S.T.C., fig. 10B). Beginning almost at the tip of the tail as a closed canal (not, as Garman states, "a furrow"), the lateral canal runs forward, on a level just beneath that of the vertebral bodies of the vertebrae. This canal runs slightly dorsally and in the region of the base of the tail lies at the same level as the vertebral bodies. From here it continues forward at this level till it reaches the region of the pelvic fin, where it begins to run more towards the dorsal surface, until finally, just behind the supra-orbital crests, it is actually on the dorsal surface (LAT. L., figs. 10B, 11). Between the supra-orbital crests the two lateral canals turn slightly medially and join the supra-temporal canal (S.T.C., fig. 10B) which runs transversely across the head just behind the openings of the endolymphatic ducts.

Running forward from the junction of the lateral line with the supra-temporal and extending forward, a short distance, to join the cephalic canals, is a small canal which Goodrich (1930) maintains is not part of the infra-orbital canal as is usually stated. This temporal canal (T.C., fig. 10B) is innervated by the supra-temporal branch of the glosso-pharyngeal nerve. In *H. portusjacksoni* the buccal branch of the seventh nerve has no ramus oticus, consequently there is no part of the sensory canal which can be called the otic region.

The remaining sensory canals are all in the head region and comprise the supra- and infra-orbital canals, the hyomandibular and mandibular canals.

The supra-orbital canal (S.O.C., figs. 10B, 11) runs from the temporal canal towards the snout, medial to the supra-orbital crest. On the tip of the snout, each supra-orbital canal curves slightly inwards, towards the mid line, and then runs outward around the nasal capsule to join the infra-orbital canal in the region of the superior oral fold of the upper lip. This canal also has a branch which runs from the loop in front of the nasal aperture towards the middle of the central part of the upper lip where it joins the infra-orbital canal from its own side of the body and also the supra- and infra-orbitals of the opposite side. This junction, marked x in figure 10A, corresponds to Garman's median canal (1888) and lies in the skin of the upper lip, just in front of the symphysis of the upper jaw cartilages.

The infra-orbital canal (I.O.C., figs. 11, 12) passes from the temporal canal, behind and below the orbit to the mid-cheek region. Here it curves sharply towards the ventral region and runs a short distance downward. It then turns forward, joining the supra-orbital canal above the superior oral fold of the upper lip. From this junction the infra-orbital canal runs around the side of the nasal capsule to the roof of the mouth, where it turns inward. The canal runs around the back of the excurrent nasal aperture and then forward parallel to the upper jaw till it joins the supra-orbital canal at the point x mentioned above.

The infra-orbital canal gives off another canal which runs backward across the cheek almost to the edge of the first gill-slit. This is the hyomandibular canal (H.C., fig. 11).

Given off ventrally about half-way along the hyomandibular canal is the mandibular sensory canal which runs to the lower jaw. Though extending a considerable distance towards the mid-line, the two mandibular canals do not join up anteriorly (M.C., figs. 10A, 11).

The sensory canals open by pores to the surface of the skin at frequent intervals and they communicate with these pores by means of short tubules (T., figs. 10B, 11). The innervation of the sensory canals is described under the heading of the various branches of the nerves which run to these regions.

Ampullary Organs.—In this shark the ampullary organs are numerous and lie in the integument at a slightly deeper level than the sensory canals. Each organ consists of a pore, which opens to the exterior, connected by a tube-like canal to the sense organ proper or ampulla. The length of the tubules ranges from a few millimetres up to 5 cm. or more in large specimens of *H. portusjacksoni*.

The ampullae, which are all innervated by branches of the seventh cranial nerve, are collected together in *H. portusjacksoni* in knot-like masses much as they are in batoid forms. From these groups of ampullae tubules radiate in many directions (see figures 10A and 11).

In *H. portusjacksoni* five such groups are present. Although Norris (1929) in his paper on the ampullae of Lorenzini stated that in the Centracoidei, as an example of which he took *Heterodontus* (species not stated), there are six distinct groups, I have been unable to find his posterior outer buccal group.

The groups represented are: (1) supra-orbital, (2) inner buccal, (3) outer buccal, (4) hyoidean and (5) mandibular. The hyoidean group is compact and not in three parts in this shark, as Norris stated for his species (1929).

(1) The supra-orbital (S.O.A., figs. 10, 11) group is situated just above the incurrent opening of the nasal organ and is on the extreme tip of the snout. The tubules of the ampullae radiate in all directions and their pores lie around the

border of the nasal aperture on the triangular fold of the upper lip and also on the skin of the antero-dorsal region of the head.

(2) The inner buccal group (I.B.A., figs. 5, 12) is situated under the skin of the roof of the mouth, in the fleshy pad of tissues which lies lateral to the upper jaw cartilage and behind the excurrent opening of the nasal capsule. It has very few ampullae and the tubules are about nine in number. The pores open on this fleshy pad and thus lie in the path of the water flowing out of the nasal capsule into the mouth. The ampullae are innervated by a small branch of the buccal nerve which runs around the outer side of the nasal capsule, beneath the infra-orbital canal, and so on to the roof of the mouth (R.B. VII, fig. 12).

(3) The outer buccal group (O.B.A., fig. 11) lies in the mid-cheek region between the orbit and nasal capsule and is the largest group in this shark. Tubules radiate in many directions to their pores which are distributed partly on the dorso-lateral area of the head in front of the supra-orbital crest; partly in the skin around the nasal capsule and partly to an area of skin below the eye and in front of the spiracle and partly to the lateral fold of the upper lip.

(4) The hyoidean ampullae (HY.A., figs. 10, 11) lie embedded in the integument lateral to the mid-point of the body opposite the hyoid arch. From the ampullae tubules run both dorsally and ventrally, their pores opening in an arc-like series which lies parallel to the hyoid arch. These pores extend from the spiracle to the ventral surface.

(5) The mandibular ampullae (M.A., fig. 10A) are found under the skin of the lower jaw, just behind the lateral lip fold. Their tubules run both forward and backward and their pores are scattered over the skin of this area from the mouth gape as far back as the level of the eyes.

Innervation of the ampullae has been described under the headings of the nerves which supply them.

Spiracular Sense Organ.—There is a small sense organ, associated with the spiracle, which, according to Norris and Hughes (1920), is equivalent to a much modified canal of Lorenzini.

The spiracle, in addition to its straight passage from the exterior to the pharynx, has two blind pouches leading off it, one near its upper end, the other near its lower end. The larger dorsal one leads inward and slightly backward from the external opening towards the wall of the auditory capsule which it almost touches. Nearer its internal opening on its dorso-anterior wall is the smaller ventral diverticulum. The pore of the sense organ opens into this pouch. The organ is innervated by a small branch of the buccal branch of the VIIth nerve. Goodrich (1930, p. 756, figure 732) shows this organ in transverse section in a 70 mm. embryo.

I have been unable to locate any pit-organs in this shark.

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SUMMARY.

The central nervous system and peripheral nervous system of *Heterodontus portusjacksoni* are described, as is also the structure of the pituitary gland.

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The nervus terminalis lies on the ventral aspect of the fore-brain in the adult.

The truncus infra-orbitalis in *Heterodontus portusjacksoni* is made up of the maxillary, mandibular and buccal nerves. This condition thus agrees with that found in *Mustelus* (Allis, 1901) and differs from that found in *Squalus acanthias* by Norris and Hughes (1920).

There is no otic branch to the VIIth nerve in *Heterodontus portusjacksoni.*

The description of the ampullary and sensory canals differs slightly from those given by earlier authors.

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THE DIPTERA OF THE TERRITORY OF NEW GUINEA. VI.

FAMILY STRATIOMYIIDAE.

By Erwin Lindner (Stuttgart).
(*Communicated by Frank H. Taylor, F.R.E.S., F.Z.S.*)

(Three Text-figures.)

[Read 26th October, 1938.]

Herr F. H. Taylor von der School of Public Health and Tropical Medicine in Sydney sandte mir eine kleine aber ausgezeichnete Sammlung von Stratiomyiiden aus dem nordöstlichen Neu-Guinea. (Als Fundorte werden besonders die beiden Punkte Wewak und Aitape genannt.) Da aus Neu-Guinea zwar eine ganze Anzahl Arten dieser Familie schon lange bekannt ist, Material der grossen Insel aber selten in unsere Museen gelangt, viel Neues noch zu erwarten sein dürfte und in der mir zur Bearbeitung zur Verfügung gestellten Sammlung 2 neue Formen sich befanden, gebe ich im folgenden eine kurze Zusammenstellung der Ergebnisse meiner Bestimmungsarbeit, sowie die Beschreibung der neuen Arten *Solva novae-guineae* und *Saldubella margaritifera*. Ausserdem fand sich in dem Material eine neue Subspecies von *Ptilocera fastuosa* Gerst. (Ssp. *dilutiapicis* m.), die ich zuerst von Neupommern kennen gelernt hatte, und die in anderem Zusammenhang an anderer Stelle veröffentlicht werden soll. Neu war auch, dass die im männlichen Geschlecht immer noch unbekannte, von mir kürzlich von den Salomonen beschriebene *Microchrysa chrysidiformis* auch auf Neu-Guinea vorkommt. Ebenso ist *Ruba fuscipennis* Enderl., von Lombok beschrieben, nun auch für Neu-Guinea nachgewiesen. Als besonders markante Formen hebe ich *Caenocephalus melanarius* Walk. (Text-fig. 2) und *Obrapa perilampoides* Walk. hervor, welch letztere, wohl von verschiedenen Inseln bekannt, für Neu-Guinea anscheinend neu ist.

Subfamily Solvinae.

1. Solva novae-guineae, n. sp. Text-fig. 1, Flügel.

3 ♂, 4 ♀, von Wewak. Da Tiere von Sumatra und Java z. T. mit *vittata* Dol. (de Meijere, Enderlein) identifiziert wurden, ich eine solche Identität nach der sich mehrenden Zahl orientalischer Arten aber für unwahrscheinlich halten und einen nahen Zusammenhang der von Neu-Guinea vorliegenden Stücke mit *vittata* Dol. von Amboina vermuten musste, bemühte ich mich die Zusammenhänge in dieser Gruppe etwas zu klären. Ich glaube, dass mir dies durch die Autopsie der Typen Doleschalls im Wiener Museum und den Vergleich mit den Originalstücken Enderleins im Stettiner Museum bis zu einem gewissen Grad gelungen ist.[1]

Zunächst ergab sich, dass die Serie von Wewak nicht zu *vittata* Dol. gehört. Die echte *vittata* Dol. (nach den Typen) ist dadurch ausgezeichnet, dass das Schildchen schwarz ist und dass der Streifen auf der Unterseite von f_3 von der

[1] Für die Ermöglichung des Vergleichs bin ich den Herren Kollegen Dr. M. Beier in Wien und Dr. A. Kästner in Stettin zu grossem Dank verpflichtet.

Basis bis zur Spitze verläuft und von der Seite gesehen die halbe Höhe der f_3 einnimmt.[2] Die t_3 sind ventral an der Basis schmal, am Ende breit gebräunt. Die Tarsen sind distal gebräunt, der Hintermetatarsus ist fast ganz hellgelb. Die Flügel sind im distalen Drittel, besonders gegen den Vorderrand, aber mit Ausnahme der R_1 etwas gebräunt. Das Flügelgeäder stimmt bei den beiden Stücken nicht ganz überein, insofern als bei dem einen (mit sehr verblasster Bräunung) m–cu_1 etwa der Darstellung Enderleins von 1913 entspricht, bei dem andern aber punktförmig ist (!). Das Abdomen ist ganz schwarz. Fühler an der Basis und innen bis zur Hälfte gelb, das Ende braun.

Ob de Meijeres *nigroscutata* von *vittata* (Dol.) Enderl. verschieden ist, halte ich einer Nachprüfung für wert.

Beschreibung von *Solva novae-guineae*, n. sp.

Kopf schwarz mit messingfarbener Behaarung der Stirn, fein silberweissem Saum des Untergesichts, langer weisser Behaarung des unteren Augenhinterrandes. Fühler an Basis und Innenseite rotgelb in verschiedener Ausdehnung, apikal braun. Rüssel rotgelb, Taster weisslichgelb. Thorax einschliesslich Hüften schwarz; Schultern, ein Seitenstreifen zur Flügelwurzel und das Schildchen sind hellgelb. Die feine Behaarung auf dem vorderen Teil des Mesonotums gelblich glänzend, sonst silbern. p gelb, mit gebräunten Tarsen; die Metatarsen sind grösstenteis basal noch gelb. f_3 verdickt, an der Unterseite mit vielen kleinen Zähnchen und mit einem schwarzbraunen Längsstreifen, der proximal und distal abgekürzt ist. Auf der Unterseite der t_3 hingegen geht er vom Knie bis zum Ende der t, ist an der Basis schmäler, am Ende breit. Die Flügel sind gleichmässig grau getrübt. Schwinger gelb. Das Flügelgeäder von *novae-guineae* zeigt deutliche und charakteristische Verschiedenheiten von dem von *vittata*. m-cu_1 ist kurz, fast auf einen Punkt reduziert, während bei *vittata* (von Amboina und Sumatra) m_3 und cu_1 an der Basis verschmolzen sind und D ein Stück weit begrenzen.[3] Bei fast allen Stücken der neuen Art ist am Ende der Cu_1 von dem "Stiel" $m_3 + cu_1$ nichts mehr vorhanden, nur bei dem einen oder dem andern findet sich ein ganz kurzer Stummel, der aber nicht die Hälfte des Abstandes der Cu_1 vom Hinterrande erreicht. Mehr wie bei den andern Arten ist Cu_1 an der Stelle des Aderstummels gerundet (Text-figur 1). Die Ausdehnung der braunen Zeichnung der f_3 und der t_3 schwankt etwas; bei einem ♀ fehlt sie ganz. Ausserdem ist sie in der Regel fast schwarz und beginnt an der t_3 proximal ganz schmal, erweitert sich auf der Unterseite immer mehr und umfasst das Ende in der Regel ganz, sodass auf der Oberseite nur ein schmaler, an der Basis breiter blassgelber Streifen frei bleibt.

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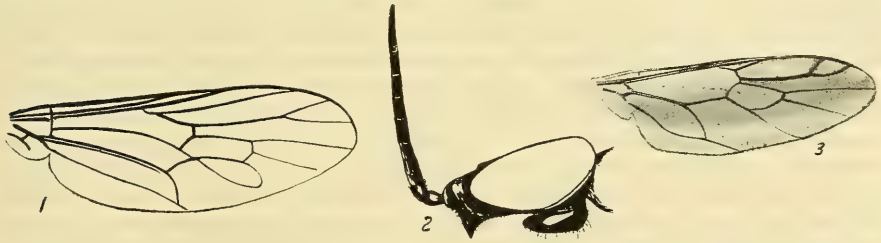
[2] Die Ausdehnung des Streifens ist übrigens Schwankungen unterworfen—bei dieser Art und bei andern—ja er kann ausnahmsweise sogar ganz fehlen! Bei Stücken von Sumatra und Java beobachtete ich solche mit einem Längsstreifen von der vollen Länge des f_3 und andere mit einem abgekürzten Streifen, der nur die letzten 4/5 einnahm.

[3] In meiner Bearbeitung der palaearktischen Stratiomyiiden (1936-1938) bei der Behandlung der Solvinen zählte ich die palaearktische Art *marginata* Meig. 1820 zu *Solva* (Gattungstype *inamoena* Walk. 1860, Celebes), übersehend, dass Professor Enderlein für die Formen mit einer regelrechten m-cu_1 oder einer punktförmigen das Genus *Hanauia* (1920) errichtet hatte, wonach in dem Genus *Solva* nur die Formen zu verbleiben hätten, bei welchen cu_1 ohne Bildung einer m-cu_1 ein Stück der D bildet. Nach dem Befunde bei *Solva novae-guineae* lässt sich diese Unterscheidung aber kaum aufrecht erhalten.

Solva und *Xylomyia* zu trennen, halte ich eher für berechtigt. Ich habe es für die wenigen palaearktischen Arten nicht getan, weil ich sonst die Tabelle *Pleskes* nicht hätte benützen können, deren asiatische Formen mir grösstenteils unbekannt geblieben sind und die nach den Beschreibungen *Pleskes* nicht immer den Schluss auf *Solva* oder *Xylomyia* zulassen.

Abdomen schwarzbraun glänzend, an den Seitenrändern und Hinterrändern ± hell kastanienbraun. Genitalapparat gelblichbraun. 5–6 mm.



1.—*Solva novae-guineae*, n.sp. Flügel, × $\frac{2}{3}$. 2.—*Caenocephalus melanarius* Walk. Kopf, × $\frac{1}{2}$. 3.—*Saldubella margaritifera*, n. sp. Flügel, × $\frac{1}{2}$.

Subfamily Geosarginae.

2. Geosargus mactans–redhibens Walk., *Journ. Proc. Linn. Soc. London*, iv, 1860, 97.

3 ♂, 17 ♀, von Wewak. Walker beschrieb *mactans* und *redhibens* als zwei verschiedene Arten. Wie sich aber durch grösseres Material feststellen liess, handelt es sich um die beiden Geschlechter einer in ganz Ostindien verbreiteten Art. Ich schrieb darüber 1937 in meiner Arbeit in den *Ann. Mag. Nat. Hist.*, Ser. 10, Vol. xx, p. 376.

3. Microchrysa flaviventris Wied., *Analecta Entom.*, 1824, 31 (*Sargus*).

1 ♀, von Wewak. Diese in Ostindien weitest verbreitete und auch von Neu-Guinea längst bekannte Art liegt nur in einem weiblichen Exemplar vor.

4. Microchrysa chrysidiformis Lind., *Ann. Mag. Nat. Hist.* (10), xx, 1937, 373.

6 ♀, von Wewak. Ich beschrieb das ♀, von den Salomonen. Leider liegen auch in dieser kleinen Sammlung nur 6 ♀ vor. Das ♂ ist noch unbekannt.

5. Ptecticus ferrugineus Dol., *Natuurkund. Tijdschr. Ned-Ind.*, ser. 4, iii (xvii), 1858, 83 (*Sargus*). *P. atritarsis* Edw., *Trans. Zool. Soc. London*, xx, pt. 13, 1915, 396.

5 ♀, von Wewak, 1 ♂, von Marprik. Diese seit 80 Jahren von einer Reihe von Punkten von Neu-Guinea bekannte Art ist wohl die Hauptart von Neu-Guinea. Die kleine Sammlung enthält 5 ♀ und nur 1 ♂; dieses stammt von Marprik (J. R. Rigby).

6. Ptecticus quadrifasciatus Walk., *Journ. Proc. Linn. Soc. London*, v, 1861, 146.

2 ♀, von Wewak und Aitape. Brunetti hat eine gute Redescription der Art gegeben. Auch sie scheint auf Neu-Guinea verbreitet zu sein. Sie kommt auch auf Amboina und Batjan vor.

Subfamily Hermetiinae.

7. Caenocephalus melanarius Walk. (Text-fig. 2, Kopfprofil), *Journ. Proc. Linn. Soc. London*, v, 1861, 272.

2 ♀, von Wewak, eines von J. R. Rigby coll. Mit dieser auffallenden Gattung und besonders ihrer Art *melanarius*, die Walker als *Salduba* 1861 beschrieb, hat sich Kertész 1909 beschäftigt. Die Zugehörigkeit zur Subfamilie der Hermetiinen steht m. E. ausser allem Zweifel. Ausschlaggebend sind das Flügelgeäder, der Bau des Fühlers und gewisse Merkmale des Kopfes. Die Type von Batjan ist im Brit. Museum nicht mehr vorhanden.

8. Hermetia laglaizei Big., *Ann. Soc. Ent. France*, ser. 6, vii, 1887, 21.

2 ♂, von Wewak, Neu-Guinea. Brunetti hat die Type in Bigots Sammlung geprüft. Er fand sie "in bad condition"; sie war in solcher schon als Bigot die Beschreibung danach gab. Herr Taylor sandte mir nun 2 wohlerhaltene ♂, sodass es möglich ist die Beschreibung Bigots und die Angaben Brunettis zu ergänzen.

♂. Die schwarze Zeichnung auf der Stirn bildet ein Kreuz mit breiten Balken; der obere kurze trägt den Ozellenhöcker und der Scheitel wird von einem weiteren braunen Querstreifen bedeckt. Die 4 Flecken der Stirn, wie überhaupt die helle Zeichnung des Kopfes und des Thorax sind grünlichgelb. Die unteren beiden Flecken der Stirn sind nur durch eine seichte braune Querfurche von den Seitenflecken des Untergesichts getrennt, die etwa nierenförmig sind und den Seitenrand der Augen nicht erreichen. Die Oberseite des Gesichtshöckers ist ebenfalls gelb. Hinterkopf schwarz, Cerebrale gelb und ebenso der obere Teil des Collare. Der schwarze Hinterkopf ist fein, anliegend, goldgelb behaart, ähnlich den 3 Haarstreifen des Mesonotums. Auf den Pleuren befinden sich 3 helle, gelbgrüne Flecken. Hüften und f ganz schwarz. t in der Basalhälfte und dorsal ausgedehnter hell gelblich, das übrige fast schwarz. Die Tarsen hell gelblich, fast beinweiss. 1. Abdominaltergit schwarz, 2. mit 2 hellen Seitenflecken, die in der Mitte eine spatenförmige Zeichnung einschliessen, die mit der Spitze in den Vorderrand eintritt. Hinterrand des 3. Tergits breit gelb. 4. und 5. Tergit rostbraun, glänzend gelblich behaart. 2. Sternit fast ganz hell, durchsichtig, 3.–5. rostbraun. Schwinger grün mit bräunlichem Stiel.

14 mm.

Subfamily Clitellariinae.

9. Negritomyia maculipennis Macq., *Dipt. exot.*, suppl. 4, 1850, 54.

4 ♂ und 4 ♀, von Wewak und von Rabaul (N. Britain). Diese Art ist fast aus dem ganzen Ostindischen Gebiet bekannt.

10. Ruba fuscipennis Enderl., *Zool. Anz.*, xliv, 1914, 22.

2 ♀, Wewak (J. R. Rigby). Terra typica ist Lombok.

11. Ruba opponens Walk., *Jour. Proc. Linn. Soc. London*, viii, 1865, 107.

3 ♂, 2 ♀, von Wewak. Eine bisher nur von Neuguinea bekannt gewordene Art.

Subfamily Pachygastrinae.

12. Ptilocera fastuosa Gerst., *Linnaea Entomol.*, xi, 1857, 332.

3 ♂, 1 ♀, von Wewak und Aitape (♀). Dieses herrliche Tier ist in Ostindien weit verbreitet.

13. Ptilocera fastuosa dilutiapicis, n. ssp.

2 ♂, 1 ♀, von Wewak. Diese neue Subspecies liegt mir aus dem Brit. Museum auch von Neu-Pommern vor; sie wird an anderer Stelle beschrieben.

14. Argyrobrithes albopilosa de Meij. (ssp.).

de Meij., *Tijdschr. v. Ent.*, l, 1907, 238 (*Wallacea*); Grünberg, *Mitt. Zool. Mus. Berlin*, viii, 1915, 46; Kertész, *Ann. Mus. Nat. Hung.*, xviii, 1921, 165.

1 ♀, von Wewak. Es stimmt nicht ganz mit Stücken überein, die ich von der Malayischen Halbinsel besitze. Die Behaarung auf dem Mesonotum und dem Schildchen ist gröber und gleichmässiger verteilt wie bei diesen Stücken, bei welchen sie mehr auf die Depressionen, vor allem die präscutellare Depression konzentriert ist. In der präscutellaren Depression und auf der Basis des Schildchens ist sie bei dem Neuguinea-Stück weniger dicht und weniger gelblich,

Geringe Unterschiede scheinen auch in der Form des Schildchens vorzuliegen, doch möchte ich auf Grund des Befundes eines einzelnen Tieres aus diesen Unterschieden keine weiteren Folgerungen ziehen, sondern nur darauf hinweisen, dass Brunetti bei Exemplaren von Ceylon ebenfalls die weniger dichte Behaarung festgestellt hat, im Gegensatz zu solchen von den Seychellen.

15. Wallacea argentea Dol., *Natuurkund. Tijdschr. Ned-Ind.*, ser. iv, iii (xvii), 1858, 82.

1 ♀, von Wewak. Weit in Ostindien verbreitete und von Neuguinea bekannte Art.

16. Evaza fulviventris Big., *Ann. Soc. Ent. France*, ix, ser. 5, 1879, 220.

5 ♂, 5 ♀, von Wewak und Wau, Neu-Guinea, Pondo, N. Britain. Von Neuguinea, den Molukken und den Bivak-Inseln bekannt.

17. Evaza scenopinoides Walk., *Journ. Proc. Linn. Soc. London*, iii, 1859, 81.

5 ♂, 2 ♀, von Wewak. Ebenfalls von Neuguinea und den benachbarten Inselgruppen bekannt.

18. Obrapa perilampoides Walk., *Jour. Proc. Linn. Soc. London*, iii, 1859, 82.

1 ♀, von Aitape. Diese offenbar seltenere Art liegt nur in einem Stück vor. Es ist ein durch seine Körperform ausserordentlich auffallendes Tier: Das kurze und breite Abdomen ist eingekrümmt und verschwindet fast ganz unter dem mit dem Thorax einen grossen Schild bildenden "Schildchen".

Brunetti gab seine Redescription nach einem ♀ ohne p_1. Diese sind bei dem mir vorliegenden ♀ beträchtlich breiter als die p_2 und p_3 und zwar ist f_1 besonders ventral messerartig, t_1 dagegen dorsal kammartig erweitert und etwas gekrümmt; der Metatarsus ist in derselben Ebene erweitert und dreimal so breit wie der Metatarsus der p_2. Im Gegensatz zu den p_2 und p_3 mit ihren hellen Tarsen ist der ganze p_1 schwarz.

Die Art war seither bekannt von Aru, Batjan, Kaisaa, Dorei und Mysol.

19. Saldubella margaritifera, n. sp. Text-figur 3, Flügel.

1 ♂, 1 ♀, von Bulolo. Kertész trennte *Saldubella* von *Salduba* Walk. auf Grund des andern Baues des 2. Fühlergliedes, das bei *Saldubella* nicht fingernagelförmig innen dem 3. Glied aufliegt. Er stellte in das Genus die beiden Arten *signatipennis* Wulp und *yombae* Kert., beide von Friedrich-Wilhelmshafen, Neu-Guinea, das auch die Heimat des reichlichen halben Dutzends der *Salduba*-Arten ist. Ich konnte in meiner Arbeit 1937 eine *Saldubella vittipennis* von den Salomonen beschreiben und finde nun in der Coll. Taylor eine nahe verwandte Art von Neu-Guinea. Auch sie hat den breiten, dunklen Streifen durch die Längsachse des Flügels. Er lässt aber alle Zellen am Vorderrand des Flügels frei, umsäumt nur ihre Adern leicht, wodurch die hellen Zellen besonders hervorgehoben werden und den von mir gewählten Namen rechtfertigen dürften.

♂. Kopf schwarz, Augen zusammenstossend; Stirndreieck und Untergesicht mit einem schmalen, weisslichen Augensaum. Fühler braun, die Basalglieder und die Unterseite des 3. Gliedes gelblich. Thorax vorn schmäler als der Kopf, mit einem deutlichen spitzen Höcker, der in die Kerbe des Hinterkopfes passt. Mesonotum und Schildchen mit einen seidigen, anliegenden, gelblichen Behaarung, das erstere an den Seiten mit spärlicher, etwas längerer, weisslicher Behaarung. Pleuren glänzendschwarz. Schildchen flach, am Rande mit etwa 20 kurzen Dörnchen, die am Ende mit einem Haarbörstchen versehen sind. p weisslich, die

distalen 2/5 der f gelblich, in Braun übergehend, die Tarsen gelblich. Flügel weisslich, durchsichtig, mit einem breiten grauen Streifen, der die Vorderrandzellen freilässt und ebenso den Hinterrand: Schwinger braun mit hellerem Stiel. Abdomen schwarz, an den Seiten mehr schwarzbraun, glänzend, in der Mitte der Tergite samtartig. Behaarung unbedeutend.

♀. Mit glänzendschwarzer, fast 1/3 Kopfbreite einnehmender Stirn. Augenhinterrand schmal, scharf gekielt. Sonst alles wie beim ♂.

4 mm.

Das Material der vorstehenden Arbeit befindet sich im Besitz des School of Public Health and Tropical Medicine in Sydney; 2 Cotypen der *Solva novae-guineae*, sowie weitere Dubletten wurden dankenswerterweise der Württ. Naturaliensammlung in Stuttgart überlassen.

Note.—The following abstract of the above paper has been furnished by Mr. F. H. Taylor.

A small but interesting collection of Stratiomyiidae, of which two species and one subspecies are new, was made by Mr. F. H. Taylor, for the most part on the north-east coast of New Guinea. One species, *Hermetia laglaizei* Bigot, previously known only from the damaged female type, is represented by two males. The new species are *Solva novae-guineae* and *Saldubella margaritifera*. *Ruba fuscipennis* Enderlein, *Caenocephalus melanarius* Walker, and *Obrapa perilampoides* Walker are recorded for the first time from New Guinea.—F.H.T.

PAPUAN DIPTERA. I.

FAMILY DIOPSIDAE.

By J. R. Malloch, Arlington, Va.
(*Communicated by Frank H. Taylor, F.R.E.S., F.Z.S.*)

[Read 30th November, 1938.]

There are many species of this family known from Southern Asia, the East Indies, Asia and Africa, and one common in North America. The only species in this collection was originally described from Celebes.

Pseudodiopsis Hendel.

Deut. Ent. Zeit., 1917, 33; Curran, *Fam. Gen. N. Amer. Dipt.*, 1934, 359 and 495 (*Microdiopsis*).

Hendel proposed this new generic concept for the reception of *Sphyracephala* (?) *cothurnata* Bigot. Curran distinguishes it from *Sphyracephala* Say by "the longer eye-stalks, with the antennae close to the eyes, no bristle on the middle of the stalk, no appendage at bend of the fifth vein, etc.".

An examination of the female before me shows that the antennae are not nearer to the eyes than in *brevicornis* Say, the type species of *Sphyracephala*, the eye-stalks are longer, the head being at least twice as wide as the thorax at level of wing bases, there is a fine hair-like bristle close to the eye-margin though farther forward than it ought to be if it were a vertical, the epistome is regularly rounded. I can detect no short sternopleural spine or process mentioned by Curran, but there is a stout spine or process on the metapleura that is thick at base, tapered apically, where it is as thick as the scutellar processes, and barely half as long as the latter. Possibly there is an error in Curran's statement, sternopleura being given instead of metapleura. As a matter of fact the only characters that might appear to warrant the segregation of the species from *Sphyracephala* are the lack of the four long vertical bristles on the frons, and the absence of the part of the fifth wing-vein beyond the outer cross-vein. The last character is quite variable in some related families.

The two concepts are distinguished from others in the family by the development of the anal vein beyond the apex of the anal cell, and the presence of a well-developed alula on the anal angle of the wing, both the free part of the anal vein and the alula being absent in other genera of the family as far as I know. How many other species placed in *Sphyracephala* have these two characters I am unable to say, but Osten-Sacken in 1882* associated *beccari* Rondani, *hearseyana* Westwood, and *nigrimana* Loew with the two under discussion in the genus *Sphyracephala*, on the basis of the two wing characters mentioned above.

This similarity of characters of the North American species and the one now in hand appears noteworthy in connection with faunal studies.

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* *Berl. Ent. Zeitschr.*, vol. 26, p. 234.

PSEUDODIOPSIS COTHURNATA (Bigot).

Ann. Soc. Ent. France, 1874, p. 115, as *Sphyracephala* with a doubt.

This is a small shiny black species, with a yellow stripe across the face and anterior surface of the pedicels of the eyes, yellow antennae, the coxae, femora except their apices, and the tarsi except the basal segment of the fore pair, fulvous yellow, the bases of the tibiae brownish-yellow. Wings greyish-hyaline, veins dark, a fuscous cloud over the area between the inner and outer cross-veins and filling apical half of the discal cell, much narrower in the submarginal cell, that does not fully attain the costal margin, and a large fuscous apical mark. These wing markings are very similar to those of the genotype, but in the latter they are smaller, especially the apical mark.

The fore femora are much thickened and have some stiff, short ventral bristles in both species. Length, 5 mm.

Type locality, Celebes. One female, Papua: Mt. Lamington, Northern Division, May, 1927 (C. T. McNamara). From the Australian Museum.

COMPARATIVE ANATOMY OF LEAVES FROM SPECIES IN TWO HABITATS AROUND SYDNEY.

By Gladys Carey, M.Sc.

(Six Text-figures.)

[Read 30th November, 1938.]

This anatomical study was undertaken in the hope that it might throw some light on the morphology of xerophytes, perhaps revealing some characteristic of stomata or venation which would be distinctive for the plants of dry habitats. The results indicate that certain features of the vascular system do depend on the habitat, but the frequency of stomata seems independent of it. However, since data on stomatal frequencies have been published for plants in other climates (Salisbury, 1927; Wood, 1934), it is useful to record here some data on stomata obtained for plants in the environs of Sydney, New South Wales.

In the course of this work an examination was made of the structure of leaves from trees and shrubs in two distinct habitats, namely (*a*) sandstone ridges and slopes, bearing sclerophylls on the exposed heights and more mesic types on the lower slopes towards the valleys, and (*b*) valleys of shale supporting mesophytic rain-forest. Particular attention was paid to the nature of the stomata and venation, the two characters most likely to have functional importance. Apart from this special emphasis, several observations resulting from the more general study seem worthy of note. These are set out in the following paragraphs.

Cuticle.—It has been a recognized fact for some time that thickness of the cuticle varies with light-intensity, so that often plants in sparsely populated, exposed communities exhibit a greater development of cutin. However, there is considerable generic variation, some plants showing a greater facility for cutin-production than others. For example, in *Angophora cordifolia* on the lower surface of the leaf, the cuticle occurs as irregular furrows and folds which completely obscure the stomata in surface view (Text-fig. 1*a*). In *Banksia spinulosa* and *Epacris microphylla* in similar habitats, the cuticle, though thick, is devoid of ridges.

Thickness of leaf.—Although within any one species the percentage of thickness occupied by palisade tissue is controlled by light, there is between species a considerable variation in the absolute thickness of the leaves, irrespective of habitat. Among sclerophylls, there are leaves such as those of *Lomatia silaifolia* (*0·5 mm. in thickness, bilateral; Text-figure 5*c*) and *Isopogon anemonifolius* (0·66 mm., isobilateral), but in the same habitat there are thin leaves as seen in *Epacris microphylla* (0·25 mm., Text-figure 5*f*) and *Banksia spinulosa* (0·25 mm.). Similarly fluctuations are found among the rain-forest types. In *Eugenia Smithii* (0·36 mm.) and *Doryphora sassafras* (0·35 mm., Text-figure 5*b*), the leaves are thicker than those found in *Palmeria scandens* (0·23 mm.) and *Claoxylon australe* (0·23 mm., Text-figure 5*a*).

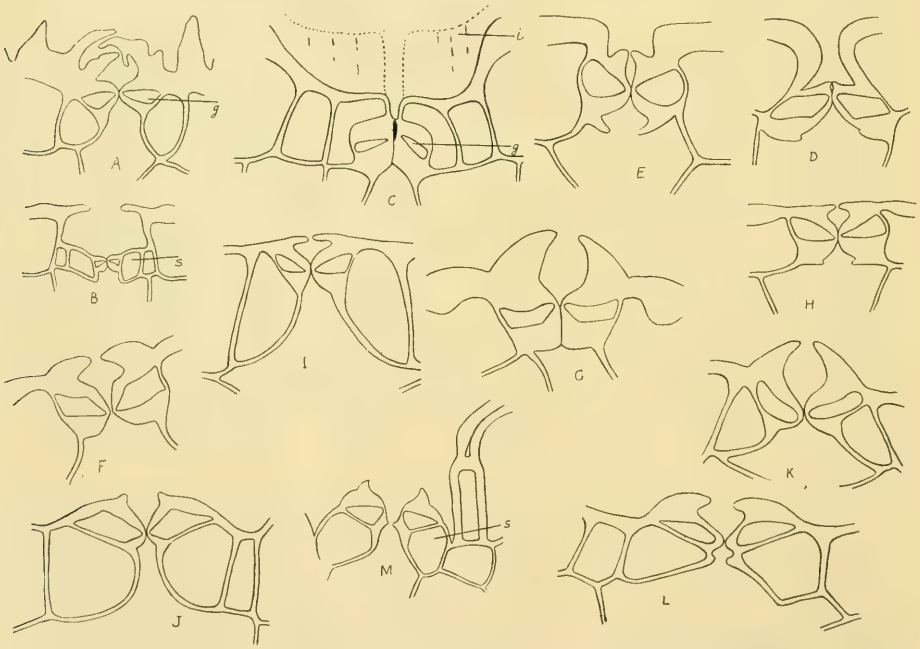
* These figures are the average of 50 counts, 5 on each of 10 leaves, representing at least 5 plants.

Sclereids.—Branched sclereids are formed in the mesophyll of the leaves of some genera. The most striking development of these cells among the leaves examined is shown in *Hakea saligna*, a lanceolate leaf, in which the palisade tissue is penetrated by branching sclereids extending from the epidermis to the spongy mesophyll. These cells are so extensive and numerous that they form, as seen from surface view, an interlocking system on both sides of the leaf (Text-figure 2); while in *H. gibbosa*, an acicular leaf, the sclereids are far fewer and dumb-bell shaped. Another genus which exhibits this feature is *Isopogon*. In *I. anemonifolius* branching sclereids are abundant in the spongy mesophyll, some projecting into the palisade; they are present also in *I. anethifolius*, but far fewer in number. The leaves of *Lomatia* are strengthened by these cells, occurring in both the rain-forest type, *L. Fraseri*, and the sclerophyll type, *L. silaifolia*.

The extent and nature of the cells in the bundle-sheath vary in the different genera. This will be discussed later in connection with the investigation of vascular tissue.

Morphology of Stomata.—Among the plants used in the determination of stomatal indices, there is wide variation in stomatal type. A description of the morphology of some stomata as seen (*a*) in section, (*b*) in surface view, will perhaps add emphasis to the conclusions reached.

(*a*) *In transverse section.* Two of the more extreme types of sunken stomata are shown in the genera *Hakea* and *Eucalyptus*. In *Hakea gibbosa* the guard



Text-figure 1.—The stomata shown in figures 1*a*-1*m* are freehand sketches; accordingly the magnifications do not allow comparison of size between the individual sketches.

a, Angophora cordifolia (G = guard cell); *b, Hakea gibbosa* (S = subsidiary cell); *c, Bossiaea scolopendria* (I = incrustation); *d, Gompholobium latifolium*; *e, Pultenaea stipularis*; *f, Isopogon anemonifolius*; *g, Hemigenia purpurea*; *h, Dodonaea triquetra*; *i, Ceratopetalum apetalum*; *j, Palmeria scandens*; *k, Doryphora sassafras*; *l, Lomatia Fraseri*; *m, Banksia spinulosa* (S = stalk cell).

cells are reduced in size and are held at the centre of the base of an extremely large air-cavity formed by over-arching of the cuticle, by several small epidermal cells (Text-figure 1*b*). These in surface view are not in focus with the larger interstomatal epidermal cells, thus making an accurate count of the total number of epidermal cells per unit area extremely difficult. In *Eucalyptus haemastoma*, the guard cells are well below the leaf-surface, although situated in the plane of the outer limit of the epidermal cell-cavities. This is due to the thickening of the outer walls of the epidermal cells and to a great thickness of cutin. An unusual type of stoma is found in the cladode of *Bossiaea scolopendria*; it lies at the base of a depression four cells wide and is protected by a flaky, colourless incrustation on the surface. The walls of the guard cells are exceptionally thick and can be seen in surface view only by focusing through the adjoining epidermal cells, which arch over them (Text-fig. 1*c*). Another type of depressed stoma is characteristic of *Gompholobium latifolium*, where the guard cells lie at the bottom of an air-chamber formed by the walls of the adjoining cells (Text-fig. 1*d*). A somewhat similar stoma is found in *Pultenaea stipularis* (Text-fig. 1*e*).

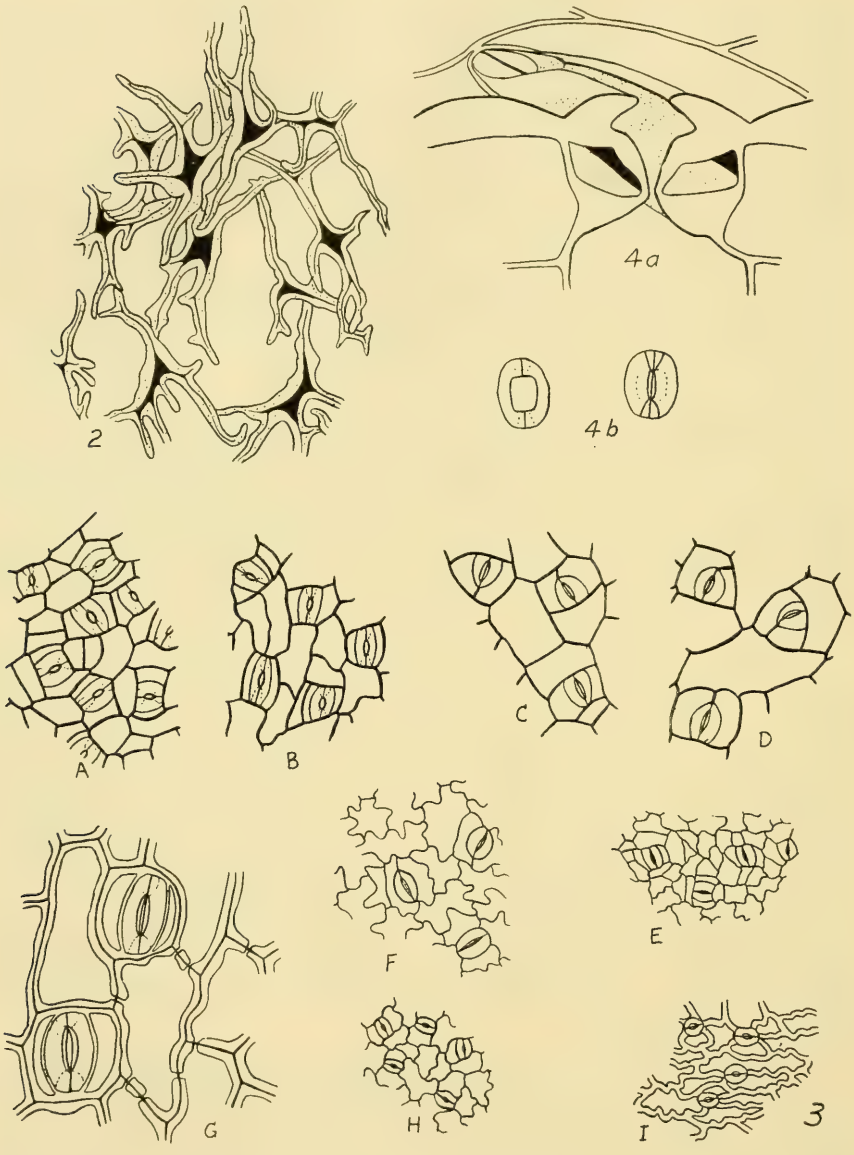
The sunken stoma is not, however, a feature of all sandstone plants. Quite a number show guard cells on the level of the epidermal cells, with the cuticle slightly arched, e.g., *Isopogon anemonifolius* (Text-fig. 1*f*), *Persoonia, Leptospermum* and *Hemigenia purpurea* (Text-fig. 1*g*). Similar stomata are of common occurrence among rain-forest species, e.g., *Dodonaea triquetra* (Text-fig. 1*h*), *Trochocarpa laurina, Synoum glandulosum.* In *Ceratopetalum apetalum*, on the other hand (Text-fig. 1*i*), the only unusual feature is the extreme difference in size between the guard cells and the adjoining epidermal cells.

In addition to the above types there are those with slightly raised stomata, e.g., in the rain-forest: *Palmeria scandens* (Text-fig. 1*j*), *Claoxylon australe, Doryphora sassafras* (Text-fig. 1*k*). On the sandstone this type of stoma on a glabrous leaf is most nearly approached in *Angophora cordifolia*, which bears guard cells level with the outer limit of the epidermis but protected by a series of overlapping arches of cuticle (Text-fig. 1*a*). Raised stomata on tomentose leaves are not infrequently found. For instance, in the recurved leaf of *Banksia spinulosa*, among the woolly unicellular hairs are guard cells raised above the general level of the epidermis by "stalk cells" (Text-fig. 1*m*). This type of stoma is mentioned by McLuckie and Petrie (1927). Similar stomata are found on the recurved leaves of *Lambertia formosa* and *Helichrysum diosmifolium.*

Thus it would seem that the position of the guard cells in relation to epidermis is not a sure guide to the nature of the habitat of the plant except perhaps in extreme cases. This has been demonstrated by Cannon also (1924) in plants of the arid regions of South Africa.

(*b*) *In surface view.*—An examination of surface sections of these leaves shows that for each genus there is a specific arrangement of the epidermal cells about the stomata. This can most readily be demonstrated by the observation of several text-figures. Text-figures 3*a* and 3*b* show the lower epidermis of two species of *Lomatia, L. silaifolia* from the sandstone and *L. Fraseri* from the rain-forest. The similarity of arrangement is self evident. Again, Text-figures 3*c* and 3*d* indicate the close agreement between cells of *Pultenaea elliptica* and those of *P. stipularis.*

The size of the epidermal cells depends upon the interaction of environment and heredity. This is illustrated by the fact that small and large cells are found among the species of plants in both habitats. *Sloanea australis*, a large-leaved member of the rain-forest flora, may have as many as 3,275 cells per



Text-figure 2.—Branching sclereids of *Hakea saligna* as seen in surface view of leaf. (× 150.)

Text-figure 3.—Surface view of the epidermal cells and stomata on the lower side of the leaf of: *a, Lomatia silaifolia*; *b, Lomatia Fraseri*; *c, Pultenaea elliptica*; *d, Pultenaea stipularis*; *e, Sloanea australis*; *f, Claoxylon australe*; *g, Persoonia salicina*; *h, Rhodamnia trinervia*; *i, Lysinema pungens.* (× 150.)

Text-figure 4.—*a,* A reconstruction of a half stoma of *Isopogon anemonifolius* (freehand); *b,* Surface view of stoma of *Isopogon anemonifolius* at two depths of focus (freehand).

square millimetre (Text-fig. 3*e*) on the lower surface, *Ceratopetalum apetalum*, 3,131 per square millimetre; while other members of the same community, such as *Claoxylon australe*, have as few as 749 per square millimetre (Text-fig. 3*f*) and *Rhipogonum album*, 611 per square millimetre. In the sclerophyll forest the variation is just as marked, in fact it so happens that the largest epidermal cells examined belonged to genera of this habitat. This is clearly indicated by the counts in leaves of *Persoonia*, which show an average of 208 cells per square millimetre in *P. pinifolia*; and of 127 and 133 per square millimetre on the upper and lower sides respectively in *P. salicina* (Text-fig. 3*g*). Small numbers are also found in species of *Pultenaea*, e.g., *P. stipularis* has an average of 395 per square millimetre and *P. elliptica* of 510 per square millimetre (Text-figs. 3*c* and 3*d*), while, on the other hand, *Lomatia silaifolia* may have as many as 1,675 per square millimetre.

The walls of the epidermal cells on both surfaces of the leaves of most rain-forest species exhibit, to a greater or less degree, convolutions or waviness of outline, as shown in *Claoxylon australe* (Text-fig. 3*f*), *Trochocarpa laurina*, *Rhodamnia trinervia* (Text-fig. 3*h*). An exception occurs in *Ceratopetalum apetalum* where this feature is absent altogether. In spite of the general nature of this feature among rain-forest plants, it is not exclusive to them; all that may be said is that, while apparently widespread in such habitats, it appears to be the exception rather than the rule among plants of sclerophyll forests. This does not preclude the influence of light on the character of these walls in any one species and it is interesting to note that, though the walls of the epidermal cells in *Lomatia silaifolia* are straight, those of *L. Fraseri* in the more shaded habitat of the rain-forest are wavy in outline (Text-figs. 3*a* and 3*b*). *Bauera rubioides* growing on the sandstone slopes and in the valleys shows this feature strongly, but it is just as pronounced in the leaves of *Epacris microphylla*, *Lysinema pungens* and *Persoonia salicina* (Text-figs. 3*i* and 3*g*), on the exposed sandstone ridges.

The structure of the stomata as seen from above requires no comment except in the case of that occurring in the Proteaceae, as seen, for example, in *Lomatia*, *Isopogon*, *Hakea* and *Persoonia*. In these the deposition of cutin seems to be heaviest about the pore and least about the junction of the guard cells, where it flattens out into two elliptical-shaped areas through which the contents of the guard cells can be readily seen. An attempt has been made in Text-figure 4*a* to reconstruct a half stoma in the solid, from a transverse section and surface sections at various depths of focus (Text-fig. 4*b*). The width of the air-cavity at the top of the stoma is variable. It is widest in genera such as *Persoonia* and *Lambertia*, and narrowest in types such as *Lomatia* and *Isopogon*.

The size of the stomata seems to be a hereditary factor on which the environment in each individual species exerts an influence, some species being more plastic than others. This is deduced from the fact that all sizes of stomata are found in both habitats, some of the largest belonging to the xerophytes. The semi-succulent *Persoonia* has stomata of unusual size, far larger than any other examined (Text-fig. 3*g*). The average long diameter of stomata of *Hakea gibbosa* (as determined from ten readings) measures 0·035 mm., those of *Eucalyptus haemastoma*, 0·038 mm.; while in the more humid, denser habitat the stomata of *Doryphora sassafras* are on the average 0·039 mm. in length, those of *Drimys insipida*, 0·034 mm. So there seems to be no significant difference in stomatal size among the different genera.

Stomatal Index.—In addition to the above general survey, counts were made of the epidermal cells and stomata in the same areas from which the stomatal

indices were determined. The field used was a square whose side measures 0·31 millimetre, for it was found that with a larger field accurate counting of smaller cells was almost impossible. The surface section used was taken in each case close to the middle of the leaf, in the wider leaves closer to the midrib than to the outer margin. Two branches were collected from any one plant and a leaf taken from each. The original plan was to take ten plants from several different areas, making twenty determinations in all for each species. However, this plan was not strictly adhered to, so that in some cases fewer determinations have been made. To summarize the results, the averages were obtained and their standard deviations (σ) calculated (Table 1). In this, the stomatal frequencies are included also, although it is realized from the method of sampling and the small number of counts that these figures cannot be taken as decisive; they give merely some idea of the order of frequency.

The species selected were trees and shrubs showing wide variation in height and leaf-form. In the sandstone sclerophyll forest were selected low-growing shrubs (e.g., *Platylobium formosum*, *Epacris microphylla*), taller shrubs (e.g., *Lambertia formosa*, *Gompholobium latifolium*) and trees (e.g., *Banksia spinulosa*, *Eucalyptus haemastoma*). Similarly in the rain-forest, low shrubs (e.g., *Rhodamnia trinervia*, *Drimys insipida*), tall shrubs (e.g., *Dodonaea triquetra*, *Lomatia Fraseri*) and trees (e.g., *Palmeria scandens*, *Doryphora sassafras*). These plants also exhibit divergence in leaf-form, ranging from small closely-set leaves (*Lysinema pungens*) to broad, well-spaced leaves (*Persoonia salicina*, *Angophora cordifolia*) and include dissected laminae (*Isopogon*), terete leaves (*Hakea gibbosa*, *Hemigenia purpurea*), narrow recurved leaves (*Banksia spinulosa*) and cladodes (*Bossiaea scolopendria*). In the rain-forest the variation includes the comparatively narrow leaves of *Lomatia Fraseri* and *Drimys insipida*, with gradations to the very broad leaves of *Sloanea australe* and *Rhipogonum album*.

In Table 1 it will be noted that in one instance, namely for species of *Pultenaea*, the stomata are found only on the upper side of the leaf. This is associated with the position of the leaves on the stem, for they are crowded together at an acute angle so that the under surface is the most exposed. This unusual position of the stomata is attended by the presence of one or two layers of colourless cells derived from the lower epidermis and separating it from the mesophyll in *P. elliptica* and similarly derived tannin cells in the same position in *P. stipularis*. Owing to the extreme difficulty in dealing with xeromorphic tomentose leaves which, if narrow (e.g., *Banksia ericifolia*), are often recurved; and if wide (e.g., *Banksia serrata*, *B. latifolia*), are depressed between the veins, stomatal counts are given for such a type only in one instance, namely, *Lambertia formosa*.

Salisbury (1927), in a paper on stomatal frequencies of British plants, introduced the concept of *stomatal index** for a number of plants from various habitats, from which he deduced "that high humidity tends to reduce the proportion of stomata found and aquatics would appear to have low stomatal indices". This is not, as a matter of fact, borne out by statistical analysis of Salisbury's data (Table 2), but it is noteworthy that there is a statistically significant difference between the stomatal indices of British woodland plants and those of the species investigated from the New South Wales rain-forest. The difference between the stomatal indices of British woodland plants and New South Wales sclerophyll forest types, is not so marked owing to the higher standard deviation in the latter.

* i.e., the percentage of epidermal cells which are stomata.

TABLE 1.

Stomatal frequencies, stomatal indices and percentage areas of leaf surface occupied by vascular tissue.

Sclerophyll Forest

on sandstone ridges and slopes.

Plant.	Type of Leaf.	S.F.u.	S.F.*l*.	S.I.u.	σ Mean.	S.I.*l*.	σ Mean.	V.B.	σ Mean.
Banksia spinulosa	narrow, recurved	—	—	—	—	—	—	52	1·66
Hakea gibbosa	terete	73	73†	7·1	0·92	7·1	0·93	—	—
Hakea saligna	lanceolate	(*f*)	94	—	—	7·4	1·14	—	—
Isopogon anemonifolius	dissected, flat	187	125	12·9	1·10	10·5	1·28	42	6·46
Isopogon anethifolius	dissected, terete	104	77	10·8	1·59	9·4	1·56	—	—
Lomatia silaifolia	2-3 pinnate	—	273	—	—	17·3	1·46	43	4·43
Lambertia formosa	narrow, linear, recurved	—	293	—	—	14·7	1·27	45	4·00
Persoonia pinifolia	terete, grooved above	31	31†	13·3	8·46	13·3	8·46	—	—
Persoonia salicina	broad lanceolate	20	20	12·5	2·03	12·5	2·03	33	4·61
Epacris microphylla	small, cordate-ovate	—	281	—	—	24·8	1·86	46	3·62
Lysinema pungens	cordate, tapering	—	312	—	—	19·9	2·24	40	3·48
Bossiaea scolopendria	cladode	114	114	10·6	1·01	10·6	1·01	—	—
Gompholobium latifolium	3 foliate, narrow	—	229	—	—	18·9	1·45	46	3·32
Platylobium formosum	ovate lanceolate	—	293	—	—	19·5	1·77	37	4·04
Pultenaea elliptica	elliptical-oblong	104	—	16·9	1·46	—	—	25	2·88
Pultenaea stipularis	narrow, linear	73	—	16·5	1·76	—	—	33	2·81
Angophora cordifolia	ovate, cordate base	—	—	—	—	—	—	34	4·61
Eucalyptus haemastoma	lanceolate	104	114	6·7	0·95	6·6	0·83	—	—
Leptospermum attenuatum	narrow lanceolate	281	187	11·6	1·26	9·3	2·10	—	—
Leptospermum flavescens	narrow oblong-obovate	140	146	10·4	2·45	11·9	1·73	—	—
Boronia pinnata	pinnate	(*f*)	187	—	—	23·2	2·13	23	2·28
Hemigenia purpurea	terete, grooved above	73	62†	14·3	1·24	13·0	1·36	—	—
Bauera rubioides	3 foliate, lanceolate	—	166	—	—	14·5	1·52	—	—
Helichrysum diosmifolium	narrow linear, recurved	—	—	—	—	—	—	23	3·21
	Rain-Forest.								
Lomatia Fraseri	narrow lanceolate	—	187	—	—	14·5	1·34	27	3·00
Trochocarpa laurina	ovate	—	187	—	—	14·9	3·17	29	3·79
Backhousia myrtifolia	ovate, acuminate	—	499	—	—	19·9	0·97	21	—
Eugenia Smithii	ovate, usually acuminate	—	281	—	—	9·7	0·94	17	3·06
Rhodamnia trinervia	ovate oblong, acuminate	—	510	—	—	14·9	0·62	28	0·22
Pittosporum undulatum	lanceolate	—	322	—	—	13·1	1·59	20	3·06
Doryphora sassafras	oblong lanceolate	—	94	—	—	7·7	0·94	21	2·78
Palmeria scandens	broadly elliptical	—	73	—	—	8·1	1·72	19	2·10

S.F.u = mean stomatal frequency per square millimetre (upper epidermis).
S.F.*l* = mean stomatal frequency per square millimetre (lower epidermis).
S.I.u = mean stomatal index (upper epidermis).
S.I.*l* = mean stomatal index (lower epidermis).
V.B. = percentage area occupied by vascular tissue (surface view).
σ = standard deviation from mean.
(*f*) = sometimes a few present.
† = two stomatal figures given as though the leaf were isobilateral.

TABLE 1.—*Continued.*

Plant.	Type of Leaf.	S.F.u.	S.F.*l*.	S.I.u.	σ Mean.	S.I.*l*.	σ Mean.	V.B.	σ Mean
Dodonaea triquetra	.. narrow lanceolate ..	—	198	—	—	15·0	1·84	30	2·24
Drimys insipida	.. oblong lanceolate ..	—	114	—	—	10·1	1·18	15	2·29
Claoxylon australe	.. oblong to oval, large ..	—	156	—	—	16·7	0·94	12	0·22
Sloanea australis ..	.. obovate-oblong, large ..	—	364	—	—	9·9	0·52	24	3·87
Synoum glandulosum	.. pinnate	—	83	—	—	6·4	1·23	13	1·00
Rhipogonum album	.. ovate, large	—	104	—	—	14·6	1·19	16	1·73
Ceratopetalum apetalum ..	lanceolate	—	375	—	—	10·8	1·39	29	2·90

S.F.u = mean stomatal frequency per square millimetre (upper epidermis).
S.F.*l* = mean stomatal frequency per square millimetre (lower epidermis).
S.I.u = mean stomatal index (upper epidermis).
S.I.*l* = mean stomatal index (lower epidermis).
V.B. = percentage area occupied by vascular tissue (surface view).
σ = standard deviation from mean.

TABLE 2.

Comparison of Average Stomatal Indices for various habitats.

Habitat.	Mean Stomatal Index.	σ Mean.	Source.
Aquatic and marsh (England)	10·62	6·78	Salisbury.
Woodland (England)	21·74	1·88	,,
Alpine and Arctic (England)	18·20	1·00	,,
Saltmarsh, sandstone, etc. (England)	21·68	6·72	,,
Sclerophyll forest, ridges and slopes (N.S.W.) ..	12·95	6·27	Carey.
Rain-forest (N.S.W.)	12·42	3·80	,,

Although the stomatal index is independent of the environment, as the above figures indicate, there is then a possibility that it may be characteristic of the family, or the genus. However, detailed examination of the figures shows no correlation between stomatal indices of the genera of any one family. Mostly they exhibit quite a wide range, as is shown in Table 3 below.

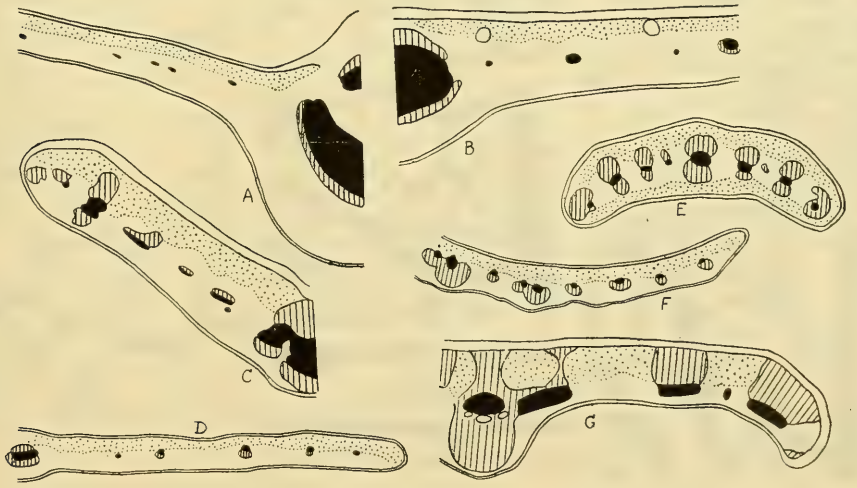
TABLE 3.

Range of Stomatal Indices in Families as shown by species examined.

Family.	Range of Stomatal Index.	Types.
Proteaceae	7·1–17·3	*Hakea gibbosa–Lomatia silaifolia.*
Epacridaceae	19·9–24·8	*Lysinema pungens–Epacris microphylla.*
Leguminosae	19·5–10·6	*Bossiaea scolopendria–Platylobium formosum.*
Myrtaceae	6·6–19·9	*Eucalyptus haemastoma–Leptospermum flavescens.*

There remains then the possibility that this factor is a characteristic of the genus. It appears that there is no wide divergence between species, even those growing in markedly different environments. For example, the stomatal index of *Lomatia silaifolia* (sclerophyll type) is 17·3, while that of *Lomatia Fraseri* (rain-forest type) is 14·5. The closest similarity is shown between species of the same habitat as is seen in *Pultenaea*, where *P. elliptica* has a stomatal index of 16·9, and *P. stipularis* of 16·5. The number of species examined is not sufficient for one to be dogmatic on this point, but the present evidence seems to indicate that stomatal index is probably an hereditary character which fluctuates to some degree, some species being more plastic than others.

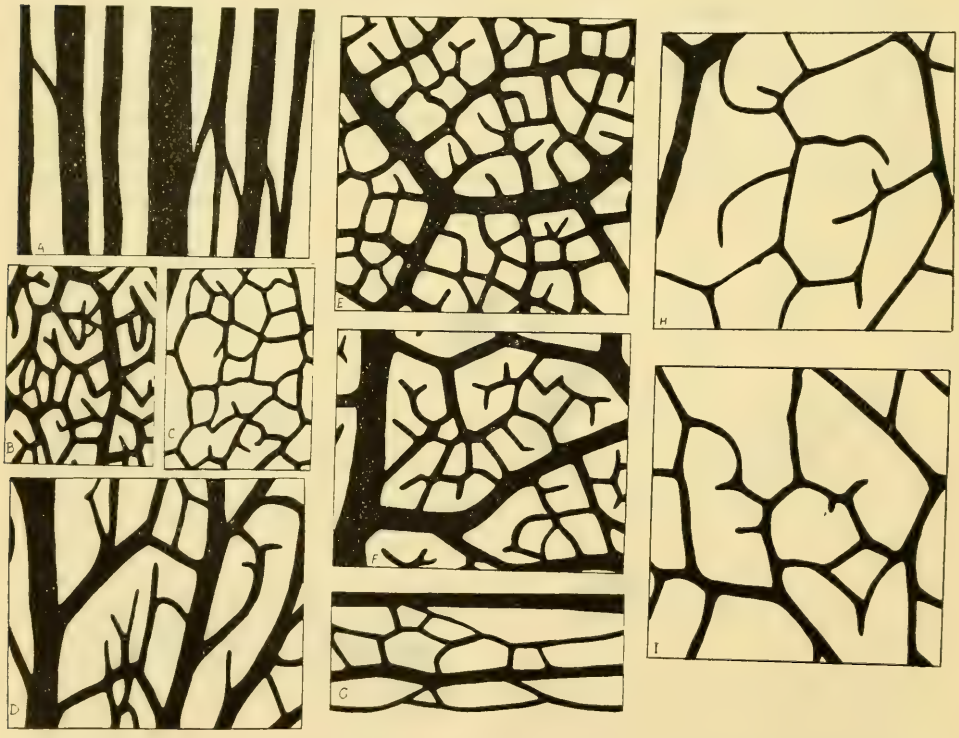
Vascular tissue of leaves.—An examination was made of the venation of the leaves, as it was considered that the number of the veins and the closeness of their mesh might be of extreme importance in the determination of the suitability of a species to a habitat (Zalenski, 1904). First, measurements were taken of the depth of the vascular bundles in relation to the thickness of the leaf, but as no consistent figures were obtained this was discontinued. It was observed, however, that there appeared to be a wider spacing of the bundles among the leaves of rain-forest types, e.g., *Claoxylon australe*, *Doryphora sassafras* (Text-figs. 5*a*, 5*b*), than among those of sclerophyll types, e.g., *Lomatia silaifolia*, *Bauera rubioides*, *Gompholobium latifolium* (Text-figs. 5*c*, 5*d*, 5*e*). Therefore, attention was concentrated on the arrangement of the veins as seen from above, and the percentage area of leaf-surface which they occupied. Ten counts were considered advisable in each species, being one from each of ten leaves, representing at least five plants. However, before the full number had been completed in each case the results seemed definite enough to conclude the investigation. The readings were determined from part of an area not more than one centimetre square, taken as near the middle of the leaf as is possible without including the midvein. These leaf segments were boiled in nitric acid, washed in water, and the epidermis and as



Text-figure 5.—Diagram of a transverse section of the leaf of: *a, Claoxylon australe*; *b, Doryphora sassafras*; *c, Lomatia silaifolia*; *d, Bauera rubioides*; *e, Gompholobium latifolium*; *f, Epacris microphylla*; *g, Lambertia formosa*. (× 25.) Black areas = Vascular tissue; Shaded areas = Fibres; Dotted areas = Palisade tissue.

much of the mesophyll as possible removed. It was obvious at once that this removal of mesophyll was much more readily accomplished in sclerophyllous types (excluding the Myrtaceae) than in rain-forest types. In the latter a sharp definition of the limit of the veins was difficult to attain. In this determination it was impossible to distinguish between bundle-sheath and conducting tissue in the sclerophyllous species, so that the figures given for the percentage of vascular tissue include the bundle-sheath. This gives a somewhat misleading impression as fibres are developed in all sclerophyllous types, being most numerous in the exposed species, e.g., *Gompholobium latifolium*, *Lomatia silaifolia*, *Isopogon*, etc. (Text-figs. 5*e*, 5*c*), and least in those growing further down the slopes, e.g., *Bauera rubioides* (Text-fig. 5*d*). In a few cases the fibres seem to spread laterally some little distance beyond the bundle, for instance, in *Epacris microphylla*, and *Lambertia formosa* (Text-figs. 5*f*, 5*g*) making its width in surface view much greater. In rain-forest plants, except for the midvein and sometimes a few other major veins, the sheath is parenchymatous.

However, camera lucida drawings were made of the venation in an area of 0·1156 square millimetre. Here again difficulty was experienced. Limitation of the area was necessary because decreased magnification and a larger area made the outline of the finer bundles uncertain and the results inaccurate. An outline



Text-figure 6.—Veins of leaves of the following plants, as seen in surface view: *a*, *Gompholobium latifolium*; *b*, *Banksia spinulosa*; *c*, *Helichrysum diosmifolium*; *d*, *Lysinema pungens*; *e*, *Angophora cordifolia*; *f*, *Platylobium formosum*; *g*, *Pultenaea stipularis*; *h*, *Drimys insipida*; *i*, *Doryphora sassafras*. (× 25.)

drawing on uniform paper was obtained, and then, by the process of cutting out and weighing, the percentage area occupied by the veins and their associated sheaths was determined. The average results for the individual species are listed in Table 1. In these determinations terete leaves and certain flat leaves in which it was thought that the results would be inaccurate, e.g., *Hakea saligna* (on account of the sclereids), were omitted.

Among the sclerophylls there is considerable variation in the type of venation. In leaves such as those of *Gompholobium latifolium* (Text-fig. 6*a*) and *Isopogon* the veins appear coarse, running almost parallel to one another, with here and there oblique veins linking them. In such cases the whole system is unbroken. On the other hand, the majority of the leaves have a more closely reticulate arrangement, with a number of short lateral vein-endings. In some types there is little variation in the diameter of the veins (*Banksia spinulosa* and *Helichrysum diosmifolium* (Text-figs. 6*b*, 6*c*)); while in other cases there is a number of well-defined lateral veins, their interstices occupied by finer bundles with a greater or less number of vein-endings, e.g., *Angophora cordifolia, Platylobium formosum, Lambertia formosa, Pultenaea stipularis* (Text-figs. 6*e*, 6*f*, 6*g*). In *Lysinema pungens* (Text-fig. 6*d*) and *Epacris microphylla*, there is a series of well-marked veins radiating from the leaf-base, between which are finer ramifications with a number of coarse vein-endings. In the rain-forest the venation is of the open reticulate type with a parenchymatous bundle-sheath, except in the case of the larger veins, e.g., *Drimys insipida, Doryphora sassafras* (Text-figs. 6*h*, 6*i*).

Table 1 shows the results of this investigation for the individual species. When these determinations are summarized (Table 4) it is found that, on the average, 37% of the leaf-area in the plants of sclerophyll forest is occupied by veins, and 21% in the plants of rain-forest.

TABLE 4.

Average percentage area of vascular tissue in leaves from various habitats.

Forest Type.	Mean Percentage Area Occupied by Veins.	σ Mean.
Sclerophyll forest of ridges and slopes	37	2·91
Rain-forest	21	6·17

Thus it is clear that there is a significant difference between the percentage of vascular tissue in the leaves of the xeric and mesic forest types. This is in accordance with the findings of Zalenski (1904), in that it indicates a parallelism between venation of a leaf and the water supply in the habitat.

SUMMARY.

1. A description is given of the anatomical variations shown in leaves taken from plants growing in sclerophyll forests and rain-forests.

2. The chief observations are those regarding stomata (in surface view and in section) and vascular tissue, as it was thought that these might show some noteworthy correlation with the habitat.

3. Tables are given of the stomatal indices of species from both environments, together with the standard deviations of their means. These are compared with the figures given by Salisbury for northern hemisphere types. They indicate

a significant difference between the mean stomatal indices of rain-forest types in England and New South Wales, but apart from this there is no relation between stomatal index and environment. The only indication of constancy in stomatal index is found among species of the same genus.

4. The percentage area of leaves, as seen in surface view, occupied by vascular tissue is tabulated. These figures show that sclerophylls exhibit a more closely reticulate venation than rain-forest types, which is in accordance with the experience of previous workers in the northern hemisphere.

My thanks are due to Professor T. G. B. Osborn, University of Oxford, for suggesting this investigation, and to Professor E. Ashby, University of Sydney, for his helpful criticism and advice in the preparation of this paper.

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AUSTRALIAN HESPERIIDAE. VIII.

DESCRIPTIONS OF NEW FORMS.

By G. A. Waterhouse, D.Sc., B.E., F.R.E.S.

[Read 30th November, 1938.]

More material has come to hand and it seems desirable to name the following new subspecies, the types of which are in the Australian Museum, Sydney.

I would draw attention to part 77 of the Lepidopterorum Catalogus, Hesperiidae, by H. H. Shepard, 1936, in which 57 species are listed, of which 52 are found in Australia. This part contains a large number of references and is remarkably free from errors. However the genotype of *Pasma* is given as Wat. & Lyell instead of Miskin, and the species *tasmanicus* (p. 13) is found in Tasmania and Victoria as well as in N. S. Wales. Also (p. 19) *T. leucostigma* is found in N. S. Wales, the holotype coming from near Sydney.

Two new records by Mr. T. H. Guthrie are: *Hesperilla malindeva* Lower at Mt. Gravat, near Brisbane, and *Hesp. idothea* Miskin at Springbrook, 3,200 feet, in the Macpherson Ranges, Qld.

Trapezites lutea Tepper, 1881.

The holotype male is from Ardrossan, South Australia, in the South Australian Museum and is in very poor condition. I have seen only six specimens from South Australia, two at Adelaide, two in the Australian Museum, and a pair in the Macleay Museum, Sydney. With the only two males known from Victoria, these are considerably smaller than those taken west of the Divide in South Queensland and New South Wales.

Trapezites lutea leucon, n. subsp.

This race is generally larger than typical *lutea* from South Australia and Victoria. The spots on the forewing above are proportionately larger, especially the opaque spot in 1*a* and the semihyaline spot in 2. The central yellow area on the hindwing is also larger and more distinct. On the underside the general colour is not quite so pure a yellow as specimens from South Australia and Victoria. The holotype male, and allotype female with paratypes are from Milmerran, S. Qld., where it has been taken by Mr. Macqueen and myself. Specimens from Binnaway, N. S. Wales, belong here. These localities are about 250 miles apart, west of the Divide.

Anisynta dominula Plotz, 1884.

The two Tasmanian races, *dominula* and *pria*, are easily distinguished, but more specimens of the larger *dominula* are required. Owing to the receipt of more material from south-eastern Australia, it is necessary to divide the continental specimens instead of keeping them all under the race *drachmophora* Meyrick, 1885.

ANISYNTA DOMINULA DRACHMOPHORA Meyrick, 1885.

The description was drawn up from a single male from Mt. Kosciusko, 3,000 feet, and is compared with *ismene* Newman, a name which I believe was never published. My specimens from Mt. Kosciusko are from about 5,000 feet and the markings on the underside are rarely silvery, but dull white or ochreous. Although Miskin mentions it in his Catalogue, 1891, from Victoria it is not recorded by Anderson & Spry in "Victorian Butterflies". It was taken this year at Mt. Buffalo (4,500 ft.) in February by Dr. Guthrie, who has given me specimens. Specimens from much further north in New South Wales are now separated as a new race.

ANISYNTA DOMINULA DYRIS, n. subsp.

This is a small race, rather grey-brown on the upperside, approaching the still smaller *pria* from Cradle Mt., Tasmania. On the upperside in the male, the forewing may have three, two or one subapical spots. On the underside the general colour is a richer brown than in *drachmophora*, the spots of the hindwing are dull ochreous, but when viewed at an angle may appear silvery. The holotype male has three subapicals above, and males and females were taken in February at Mt. Franklin (5,400 ft.), Canberra, by my nephew, D. F. Waterhouse, B.Sc.

ANISYNTA DOMINULA DRACO, n. subsp.

This is a very fine race and was taken in January, 1912, at Ebor, N. S. Wales, by the late Dr. Tillyard. It is slightly larger than *drachmophora* and the holotype male has no markings above beyond the stigma, but other specimens may have up to three subapicals, a small spot beyond the lower end of cell and a cell spot. Beneath the general colour is a rich red-brown and the chief spots silvery. I have a long series of both sexes from Ebor. I would also place here the specimens I caught at Barrington Tops, N. S. Wales, during my two trips there. Included in these are two small males, one with only five small silvery spots on the underside of the hindwing.

HESPERILLA CHRYSOTRICHA Meyrick & Lower, 1902.

Since my last part many more specimens have been received from South Australia and Victoria. Of four males and four females of the race *cyclospila* M. & L., 1902, before me from Victoria, two males and three females show the seventh spot on the underside of the hindwing as mentioned in the description of that race. Specimens from Kalangadoo, S. Australia (M. W. Mules) agree better with those from Victoria than those from Mt. Compass described below.

HESPERILLA CHRYSOTRICHA LEUCOSIA, n. subsp.

This is the race that Lower no doubt intended for *cyclospila*, 1902, but he unfortunately based his description on a Melbourne specimen with seven spots on the underside of the hindwing. It is somewhat similar to *cyclospila* on the upperside, but the central orange area of the hindwing is better defined. On the underside the general colour is nearer the red-brown of typical *chrysotricha* from Western Australia, and the silvery-white spots of the hindwing are very much smaller than those of *cyclospila*, the usual number being silver-white spots in cell, 1*a*, 2, 3 and 6, and dark dots in 4 and 5, whereas those in 4 and 5 are usually silvery in *cyclospila*. The type locality will be Mt. Compass, South Australia, in November and December, sent me by Messrs. F. M. Angel and F. E. Parsons, and I would also include here specimens from Robe, S. Australia (F. E. Parsons).

THE UPPER PALAEOZOIC ROCKS IN THE NEIGHBOURHOOD OF TAREE, N.S.W.

By A. H. Voisey, M.Sc., Linnean Macleay Fellow of the Society in Geology.

(Plate xxi; 3 Text-figures.)

[Read 30th November, 1938.]

The area which has been mapped lies between the towns of Wingham and Taree on the Manning River in the North Coast District of New South Wales. Taree is 235 miles by railway from Sydney.

It was only after the general sequence of the strata had been worked out in adjacent areas that geological mapping was found to be possible. Outcrops are not good and the boundaries of the units as indicated on the map are approximate.

Previous Literature.

In 1911 Dr. W. G. Woolnough made a reconnaissance trip through the Manning River District and briefly described limestones and possible glacial conglomerates outcropping alongside the Cedar Party Road. He compared these beds with the "Permo-Carboniferous" rocks of the Macleay River, which were described by him in the same paper.

In an account of the limestone deposits of New South Wales, Carne and Jones (1919) called all the limestones outcropping in the Manning River District "Carboniferous", probably on account of the presence of corals of that age found at Taree.

So far as I am aware this is the first attempt to describe in detail the general geology of the area and to map the beds therein.

Stratigraphy.

Devonian.

Banded claystones and tuffs of Devonian age, closely resembling those of the Tamworth Series described by W. N. Benson (1913) from the Tamworth District, outcrop south of the Manning River between the Brushy Cutting and Tinonee and north of the River between Bungay and Wingham. The beds are separated from Carboniferous strata by the Wingham Fault.

Excellent exposures occur along the road between Wingham and Tinonee, especially at the Brushy Cutting. At the north end of the Cutting is a coarse, dark green tuffaceous breccia resembling the type included in the Baldwin Agglomerates (Benson, 1913). With it are the banded claystones which, accompanied by massive beds of tuff, are seen all the way along the Cutting.

Green cherty bands are interbedded with the claystones and tuffs along the Bungay road from Wingham. The tuff bands may be traced for some distance on both sides of the road. Near Bungay a road-cutting reveals hard blue tuffs overlain by coarser tuffs which grade into a conglomerate containing rock fragments up to the size of a pea. They are associated with mudstones which weather to a

conspicuous malachite-green colour. All the beds in this Cutting dip in a direction 160 degrees at 30 degrees.

A road-material quarry on the top of the first hill east of the point where the Mount George road to Wingham crosses Dingo Creek reveals the banded claystones and tuffs which dip in a direction 100 degrees at 40 degrees.

As the banded claystones have not been examined microscopically to date, the presence of Radiolaria has not been proved. However, these organisms are abundant in similar rocks in the Tamworth (Benson, 1913) and Gloucester (Sussmilch, 1921) districts and may be expected to occur here.

So severe has been the deformation of the beds that no reliable estimate of their thicknesses has been made.

CARBONIFEROUS.

The Carboniferous sequence will be discussed under three headings: (1) Lower Burindi Series; (2) Upper Burindi Series; (3) Kullatine Series.

The Lower and Upper Burindi Series correspond with those of similar name in the Werrie Syncline and are of Tournaisian and Viséan age respectively (Carey, 1938; Carey and Browne, 1938). The Kullatine beds resemble those of the Macleay River area (Voisey, 1934*a*, 1936), but may be correlated also with the Upper Kuttung Series in the Werrie Syncline.

Lower Burindi Series.

Rocks belonging to this series outcrop on both sides of the main road most of the way between Taree and Wingham. The only reliable section which was measured extends from the vicinity of the Taree Rifle Range to Kolodong Station by way of the railway line and Kolodong road. The strata dip consistently in a north-easterly direction at angles averaging about 35 degrees.

An additional 500 feet may be added to the section by considering the succession between the Devil's Elbow and the Taree-Wingham road. It would appear from the lithology that greenish tuffs exposed in the first cutting east of Kolodong station are the equivalents of the "*Pachydomus*" horizon of Woolnough. This was located first at the Devil's Elbow railway ballast quarry (Woolnough, 1911). Such a correlation is supported by the presence of micaceous sandstones and felspathic tuffs above each massive tuff band. The "*Pachydomus*" horizon is near the base of the Kolodong section and in the middle of the Devil's Elbow section. A fault separates the two sequences and there is a violent change in strike.

The composite sequence has been calculated as follows:

	Approximate Thickness in feet.
Bluish-green tuffs with interbedded olive-green mudstones	425
Olive-green mudstones containing plant remains; bluish-green tuffs; light coloured "intrusive" tuffs; and micaceous sandstones	215
Mudstones and tuffs (inferred)	70
Sandy mudstones and greenish-grey tuffs	220
Mudstones and tuffs	145
Mudstones and tuffs (inferred)	500
Mottled and felspathic tuffs with interbedded olive-green mudstones	210
Mudstones and tuffs (inferred)	110
Felspathic tuffs, mudstones and micaceous sandstones	115
Massive greenish tuffs containing lamellibranchs ("*Pachydomus*" Horizon)	50
Tuffs and olive-green mudstones	450
Mudstones with marine fossils	20+
Total thickness	2,530+ feet

The marine fossil bed at the base of the sequence outcrops about two and a half miles from Wingham in low cuttings on the south side of the road directly opposite a road quarry in a hill to the north. The forms collected from this locality follow: *Fenestella* sp., Crinoid stems, *Spirifer* cf. *pinguis* (Sowerby), *Spiriferina cristata* Schloth., *Spirifer striata* Sowerby, *Spirifer* cf. *striato-convoluta* Dun, *Orthis* (*Schizophoria*) *resupinata* Martin, *Phricidothyris lineata* (Martin), *Productus* sp., *Conularia tuberculata* Fletcher. [Specimens F 37807–26, Aust. Museum Collection.]

Massive greenish tuffs interbedded with olive-green mudstones comprise the next 450 feet of the section. These are overlain by the first bed of the Lower Burindi Series to receive mention in literature. This is the greenish tuff which was described by Dr. W. G. Woolnough in 1911 from the Devil's Elbow. It contains a great number of specimens of a small lamellibranch which was identified by Mr. W. S. Dun as "*Pachydomus*", but as it is Carboniferous in age such a name cannot be retained. Mr. Fletcher regards it as a new form. The tuff band is fifty feet in thickness and gives rise to unusually good outcrops so that it may be traced for some distance east of the Devil's Elbow.

The greenish tuff is a very common rock-type throughout the Lower Burindi Series, but occurs in beds of varying thickness separated usually by olive-green mudstone.

A very interesting group of rocks overlies the "*Pachydomus*" horizon. Interbedded with olive-green mudstones and bands of hard greenish tuffs are felspathic tuffs and micaceous sandstones. The felspathic tuffs are in beds from several inches to a foot in thickness. One type consists of idiomorphic to sub-idiomorphic felspar crystals up to a twentieth of an inch in diameter set in a pale grey felspathic groundmass. Another is a darker grey containing white felspar crystals and stained brown in patches by iron oxides. These tuffs weather to shades of brown but often have a white surface coating. Fragmental plant-remains were found in some of the bands.

The micaceous sandstones have been examined only in a decomposed state since they are soft, porous, and readily weathered. They consist very largely of mica, with some felspar and quartz grains. A parting is well marked parallel to the lamination. The weathered colour is brown. This unusual rock occurs at intervals through some hundreds of feet of the sequence, but is usually only in beds several inches thick separated by mudstone.

On the hill just east of Wingham ferry on the Tinonee road the micaceous sandstones are interbedded with laminated mudstones which have dark and light grey bands and weather white. Arrow-head markings (Voisey, 1934*a*) are common. The dip is in a direction 120 degrees at 30 degrees.

The Kolodong section continues with olive-green mudstones and greenish tuffs with small beds of felspathic tuff for the next 1,200 feet. The mudstones do not make conspicuous outcrops since they are generally soft and crumbling, weathering readily to a buff colour. Some narrow cherty bands occur. These harder types are dark-grey or black in colour and have a conchoidal fracture. Unidentified plant-remains, usually only stems, are common in the mudstones.

The tuffs are greenish-grey or grey in colour and vary somewhat in texture and appearance. They are massive, hard, and outcrop as rounded boulders with a thin coating of the decomposed material. When more deeply weathered they become light brown or buff in colour.

A variant of the greenish-grey tuff is the mottled tuff which has a mottled appearance, the colours being shades of greenish-grey or brownish-grey. The mottling effect may have been produced through the weathering.

About 100 yards along the Kolodong road from the turn-off near the over bridge, the mudstones contain light-coloured tuffaceous material apparently intrusive along cracks. This, then, is another locality in which the phenomenon of "intrusive tuff" is developed.

A zone consisting principally of greenish-grey tuffs with subordinate olive-green mudstones comprises about 425 feet of the sequence and is splendidly exposed by the railway cutting under the overbridge on the Wingham road about two miles from Taree. It gives rise to a well-marked physiographical feature and continues southwards as a ridge into which the Manning River is cutting.

The top of this zone is regarded arbitrarily as the upward limit of the Lower Burindi since outcrops are very scarce between the tuffs and the Taree Limestone in the Upper Burindi Series.

Upper Burindi Series.

A calculated thickness of 400 feet of soft sediments occurs between the top of the Lower Burindi Series and the base of the Taree Limestone. Poor outcrops render adequate description impossible, but from the limited information available it appears that they consist largely of fine-grained sandstones and mudstones light-grey in colour and weathering buff.

A road-material quarry just east of the overbridge on the old Port Macquarie road near the limestone quarry at Taree reveals thinly-bedded, sandy mudstones and bluish-grey tuffs. Plant remains are abundant, but too fragmental for identification. The dip is variable in the quarry owing to the presence of faults. It ranges from 40 degrees to 60 degrees in directions from 350 degrees to 45 degrees.

Across the Dawson River bridge on the road from Taree to Cundletown is a small quarry on sandstones and mudstones containing crinoid stems. These resemble the Upper Burindi beds and may belong to the sub-limestone zone.

The Taree Limestone outcrops in the following localities:

1. In the railway cutting where the old Port Macquarie road goes over the railway line. (Portion 17, Parish of Taree.)

2. On both sides of the old Port Macquarie road just east of the cutting mentioned above. (Portion 18, Parish of Taree.)

3. In a quarry situated about a quarter of a mile north of the railway line near the point where it is crossed by the Wingham road about two miles north of Taree. (Portion 1 and M.L.1, Parish of Taree.)

4. In a quarry just west of the Cedar Party road near its junction with the Taree–Wingham road about three miles from Taree. (Portion 77, Parish of Taree.)

A gully through portion 78 indicates that the limestone is continuous between the two last-named outcrops.

The two first-mentioned occurrences may be lenticular beds but, most probably, they are faulted portions of the more continuous bed to the west. It is a reasonable assumption that more limestone occurs in this neighbourhood but does not outcrop.

Woolnough (1911, p. 66) described the limestone from the Taree Rifle Range, presumably from the third locality cited or thereabouts. He stated that the greyish-brown oolitic rock passed into handsome reddish marble along the Cedar Party road. This marble, however, belongs to the Kamilaroi sequence, the Cedar Party road crossing over from one limestone band to the other. Carne and Jones (1919, pp. 273, 274) described the Taree Limestone and quarrying operations carried out upon it. Like Woolnough, they regarded the deposits along the Cedar Party road as continuations of the same belt.

The limestone is light grey, dark grey or greyish-brown in colour, massive and oolitic in places. Crinoid ossicles are frequently found and corals have been reported from the Taree quarry on portion 18, Parish of Taree. These are as follows: *Aphrophyllum hallense* Smith (David, 1932, p. 59; Hill, 1933, p. 73), *Aphrophyllum* cf. *hallense* Smith (Collected Dr. G. D. Osborne. Exhibited to Roy. Soc. N.S.W., 1930), *Carcinophyllum*? (Collected by W. M. Allan. Identified Dr. I. Brown), *Lithostrotion stanvellense* Eth. fil. (Collected Dr. G. D. Osborne. Identified Dr. I. Brown), *Lithostrotion columnare* Eth. fil. (Collected Dr. G. D. Osborne. Identified Dr. I. Brown).

The corals indicate a Viséan age for the Taree Limestone.

Occasional bands of calcareous shales are present in the limestone unit and together with it make up a thickness of about 200 feet in places.

Poor outcrops characterize the mudstones and sandstones which overlie the Taree Limestone. A thickness of about 150 feet is inferred in the vicinity of the Taree Rifle Range, but a greater thickness is suggested further to the east where there is a greater extent of country between the limestone and the base of the Kullatine Series.

The total measured thickness of the Upper Burindi Series is of the order of 750 feet, but possibly the thickness reaches 1,000 feet in places.

Kullatine Series.

A belt of rocks belonging to the Kullatine Series runs from the Dawson River just north of Taree in a north-westerly direction to Cedar Party Creek. Similar beds outcrop to the north of Wingham and run northward through Khatabunda to form a high ridge. Owing to their resistance to erosion, members of this series always tend to form hills while the adjacent rocks of the Upper Burindi Series and Macleay Series are easily eroded and give rise to lower country on each side.

The Kullatine Series consists principally of tuffs and tillites, but the olive-green mudstone so typically developed in the Lower Burindi Series is absent.

A conglomerate which runs through the Taree Rifle Range and continues south-east to the railway line about two miles north of Taree has been taken as the basal bed of the series. This conglomerate is dark grey in colour, weathering to white and light-grey. It consists of well-rounded pebbles of chert, quartzite, felsite, quartz, and other hard rocks set in a tuffaceous matrix. These pebbles are usually less than four inches in diameter and commonly are 1 to 1½ inches. The smaller fragments comprise felspar, chert, quartz, and tuffaceous chloritic material.

North of Taree the conglomerate is overlain by gritty tuffs and fine-grained conglomerates into which the coarser bed passes without any well-defined line of demarcation. Small rounded pebbles are scattered throughout the next few hundred feet of the sequence and indicate sorting of the material by running water.

Some of the gritty tuffaceous rocks consist of sub-angular and rounded quartz and chert grains less than one-tenth inch in diameter set in a groundmass of green chloritic material. In other lighter-coloured types the pebbles are mostly chert, probably of volcanic origin, and are angular to sub-angular in shape. They grade into breccias and tuffaceous conglomerates, with increases in the size of the rock fragments.

Most of these rocks are white, cream, and light or dark green, but on weathering they are stained brown by iron oxides. Higher in the sequence the tuffs become darker and finer in grain. They are frequently grey and dark green and are associated with bands of green chert containing fragmental plant remains

which suggest the presence of *Rhacopteris*. No definite identifications of the fragments could be made.

The conglomerates, tuffs, and cherts are overlain by tillite with some tuff beds. It is interesting to note that the tillite was first mentioned by Woolnough (1911), who suggested that a "bluish gritty bed, almost a breccia in places", immediately below the Cedar Party Limestone might be glacial in origin. The tillite is dark bluish-grey in colour and is speckled with numerous angular and sub-angular inclusions of granites, felsites, andesites, cherts, quartzites, tuffs, and other rock types. The larger pebbles are rounded, suggesting water-sorting of some of the material. A much better development of the glacial rock is found elsewhere in the Manning River District, and at Taree its thickness is less than that measured at any other place. A particularly spectacular occurrence is that near Khatabunda Trigonometrical Station.

The tuffs interbedded with the tillite are generally dark grey or bluish-grey, massive, and of variable grainsize. Some of the finer-grained phases may pass into varve-shales, but no definite evidence of these rocks was found. Tuffs occupy the topmost portion of the sequence beneath the Macleay Series.

A section of the Kullatine Series was measured across the hills behind the Taree Rifle Range.

	Approximate Thickness (feet).
Tuff with subordinate tillite	500
Tillite	200
Fine-grained grey tuffs	50
Pale blue cherty tuffs	140
Grey tuffs	150
Conglomerates and gritty tuffs	300
Total thickness	1,340

The beds dip in a direction 25 degrees at 45 degrees. The light-coloured beds are grouped with the conglomerates and gritty tuffs at the base of the section but they apparently increase in thickness to the east. The tillites thicken to the west but it is not considered likely that the tillites and tuffs pass into one another laterally.

KAMILAROI.

Macleay Series.

Immediately above the tillites and tuffs of the Kullatine Series between Taree and Cedar Party are conglomerates or tuffs constituting the lowest beds of the Macleay Series. The conglomerates are discontinuous, but, when present, are very interesting. One outcrop occurs behind the Taree Rifle Range overlying the section which was measured in connection with the Kullatine Series. This rock consists of angular, sub-angular and rounded pebbles of granite, granite-porphyry, tuff, chert, quartzite, quartz, etc., reaching a diameter of 6 inches.

Crinoid stems and *Monilopora* were found in the matrix of the conglomerate.

The tuffs are purple in colour and speckled with yellow, white, red, and green, so that they have a somewhat spectacular appearance. Pebble bands in these tuffs are common. Sponge spicules occur in a bed at the top of this unit and coarser tuff beds containing marine fossils follow. The forms collected from these beds include: *Productus* sp. indet., *Linoproductus springsurensis* Booker, *Linoproductus cora* var. *farleyensis*, *Platyschisma rotundatum* Morris. (Specimens F 38043–44, Aust. Museum Collection.)

Soft green tuffs overlie the fossiliferous beds and, in turn, are succeeded by the Cedar Party Limestone. This rock is light grey, pink or reddish in colour and is crystalline, resembling a marble. It contains, however, very well preserved marine fossils and consists largely of the remains of crinoids. Forms collected from the belt are as follows: *Fenestella* spp. indet., *Stenopora* (small dendroid form), Crinoid stems, *Aviculopecten* sp., *Eurydesma* sp.

Dr. Dorothy Hill has identified corals from the limestone as *Zaphrentis* sp., *Michelinia* sp. (probably related to *M. indica* Waagen & Wentsel from the Permo-Carboniferous of the Salt Range, India), and *Euryphyllum* sp. Hill.

She states that the crinoidal limestone is probably that which characterizes the Cyathaxonia phase of the European Carboniferous or Permian.

The limestone is overlain by soft grey micaceous mudstones which are notorious for their failure to outcrop, being found only in cuttings and on recently eroded slopes. They give rise to a pale-grey micaceous soil, sandy in places, and this is indicative of the presence of the beds.

The following section was measured along the Cedar Party road about half a mile north of its junction with the Taree–Wingham road at about three miles from Taree.

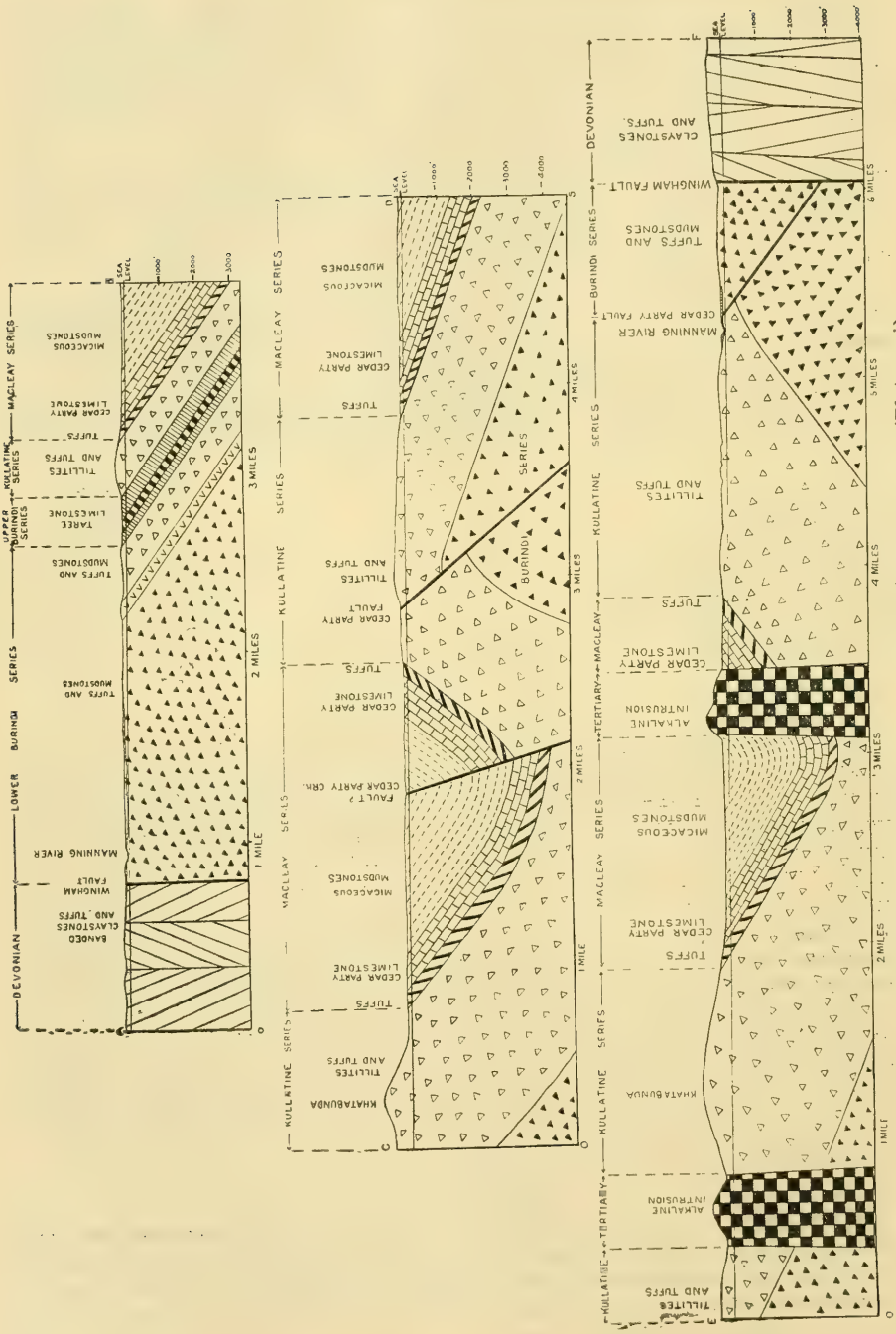
	Thickness in feet.
Micaceous mudstone	?
Cedar Party Limestone	400?
Soft green tuffs with marine fossils	55
Coarse tuff with marine fossils	30
Tuff with *Linoproductus*, etc.	10
Tuff with sponge spicules in chalcedony	10
Speckled pebbly tuff	70
Total thickness	575 + feet

Carne and Jones (1919) recorded a number of outcrops of limestone in the parish of Wingham. These may be connected with each other to form a synclinal structure striking ENE–WSW and pitching to the ENE. The northern limb runs towards the Comboyne while the southern swings round towards the Manning River. The best exposures are found between Stony Creek and the Wingham Rifle Range. West of the Rifle Range the limestone is underlain by pebbly tuffs containing marine fossils. These tuffs correspond to those on the Taree–Cedar Party road, but differ from them in appearance, being harder and grey in colour. Associated with them east of the Rifle Range between the Wingham–Comboyne road and Western's Quarry is a conglomerate containing spirifers.

Few outcrops of beds overlying the limestone have been found, but about three miles from Wingham beside the Comboyne road a coarse tuff containing crinoid stems outcrops. This is in a position where micaceous mudstones might be expected. It is necessary to point out, however, that the faulting which is prevalent in the area could give rise to anomalous occurrences which, on account of the poor outcrops, often defy satisfactory explanation.

Pleistocene to Recent.

High-level river-gravels are seen alongside the Wingham–Taree road near the junction with the Wingham–Cedar Party road and they cover nearly a square mile of country near Kolodong. These gravels are comparable with those found in the valleys of all of the coastal rivers and have a similar history (Voisey, 1934*b*). They are probably Pleistocene in age.



Figs. 1-3.—Sections along lines AB, CD, and EF on map (Plate xxi).

Terraced alluvial flats beside the Manning River belong to the present cycle of erosion and attain a width of nearly a mile.

Igneous Rocks.

Tertiary.

Alkaline Intrusives.

Two plugs of alkaline rocks occur within the area shown on the map. One gives rise to the hills in the Rifle Range at Wingham and the other constitutes a small knob just south of a branch road which runs westward off the Mooral Creek road a mile west of its junction with the Wingham–Comboyne road.

These plugs are members of a group of intrusions which have been injected into the sediments in many places between Wingham and Wauchope, notably near Upper Lansdowne. Several of them invade Triassic beds and they are believed to be Tertiary in age.

It is hoped that it will be possible to make a petrological study of these rocks at a later date.

Structural Geology.

1. *Devonian.*

On account of their relative incompetence the Devonian beds have yielded to the stresses applied to them to the extent that they have been thrown into a series of folds of small amplitude. The axes of the folds have been variable, but between Wingham and Tinonee an east–west trend has been maintained. All the folds examined have been so severely faulted at the crests of the anticlines and troughs of the synclines that the beds in those positions are vertical or overturned. Some idea of the intensity of the folding may be gained by a study of the railway cuttings between Wingham and Killawarra and of the Brushy Cutting section.

2. *Carboniferous and Kamilaroi.*

The Carboniferous and Kamilaroi strata have been folded on a meridional axis into anticlines and synclines. So great was the pressure, however, that fracturing took place and the folds are broken and deformed.

The Carboniferous beds between Kolodong and Cedar Party Creek occupy the core of an anticline pitching in a northerly direction and fractured by the Cedar Party Fault.

The Kamilaroi beds along the Wingham–Comboyne road and those east of the Taree–Cedar Party road are in synclines on each side of this anticline. The Cedar Party Limestone is a useful horizon for indicating these structures since it swings round in conformity with them.

With the exception of the Wingham Fault all the fractures indicated on the map appear to be related to the folding. The southerly dip of the beds in the neighbourhood of the Devil's Elbow is not in accordance with the anticlinal structure.

The positions of the faults in that locality, as shown on the map, are approximate only, but wherever they are placed it is a matter of some difficulty to explain their presence and the anomalous dip of the beds.

3. *The Wingham Fault.*

The Wingham Fault is a most important structure separating Devonian from Carboniferous and Kamilaroi beds. It cuts across the folded structures and is evidently younger. It appears to be a normal fault.

Age of the Folding and Faulting.

Since the folding involves beds of Kamilaroi age it must have taken place some time after the close of the sedimentary phase of that period. Triassic beds unconformably overlie folded Carboniferous and Kamilaroi beds a short distance to the north of the area. It is apparent, therefore, that the folding and the faulting associated with such folding took place during the diastrophic period at the close of the Palaeozoic Era—The Hunter–Bowen Movement (Carey and Browne, 1938).

The Wingham Fault probably belongs to the later stages of the orogeny, but there is no definite evidence to prove that it was not formed at a much later date.

There is nothing to indicate that the Devonian beds suffered any folding prior to the deposition of the Carboniferous and Kamilaroi beds.

Acknowledgements.

I desire to thank Professor W. R. Browne and Dr. G. D. Osborne of the University of Sydney for their help and advice in connection with the compilation of the manuscript.

My thanks are due also to Dr. Ida Brown, Dr. Dorothy Hill and Mr. H. C. Fletcher for identifying the fossils. Mr. Fletcher has kindly catalogued them and included them in the Australian Museum Collection.

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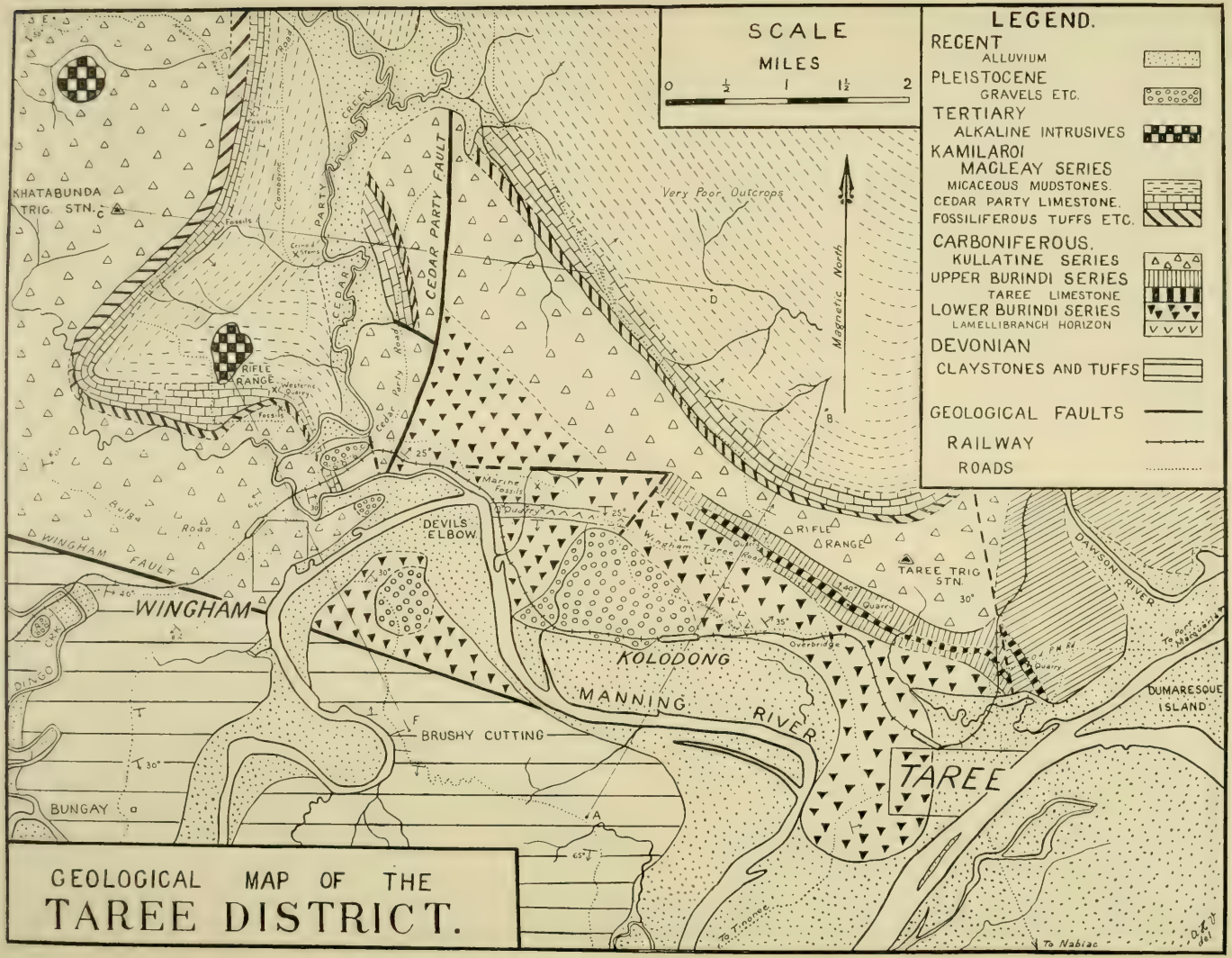


GEOLOGICAL MAP OF THE
TAREE DISTRICT.

THE GEOLOGY OF THE ARMIDALE DISTRICT.

By A. H. Voisey, M.Sc., Linnean Macleay Fellow of the Society in Geology.

(Two Text-figures.)

[Read 30th November, 1938.]

The City of Armidale is situated on the New England Tableland, 360 miles by railway from Sydney.

In connection with investigations into the stratigraphy of the Upper Palaeozoic rocks of New South Wales, the writer had occasion to pay two visits to the district during the early part of 1938.

Preparation of a sketch-map was facilitated by the presence of numerous roads. This map must be revised when it is possible for more accurate work to be carried out. It is suggested that the rock boundaries could be surveyed by the geology students of the educational establishments in the district.

The heights indicated on the map were obtained by means of an aneroid and are approximate only.

Stratigraphy.

Carboniferous (?).

(1) Mudstones, Sandstones and Tuffs.

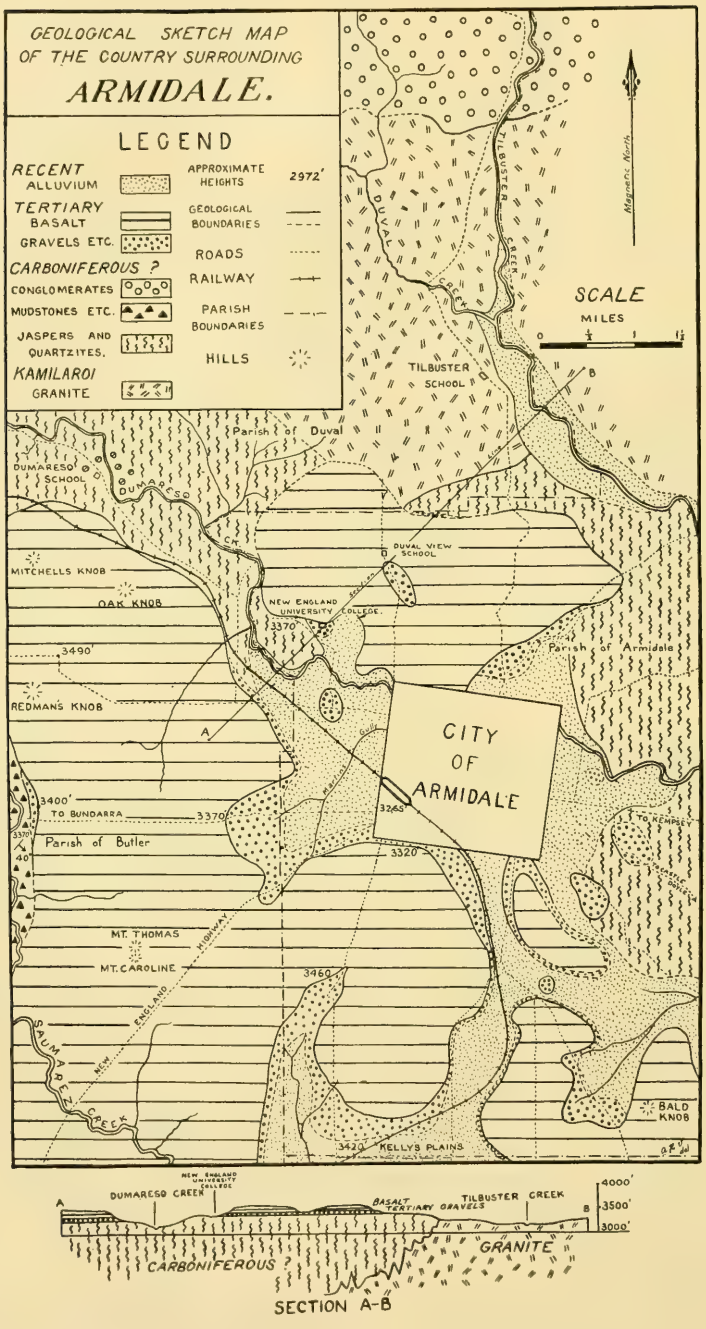
Sedimentary rocks outcrop around the bridge over Saumarez Creek, where it is crossed by the Bundarra Road, 4½ miles west of Armidale. These consist of thinly-bedded mudstones and tuffaceous (?) sandstones, together with occasional thicker bands of tuff. The mudstones are grey when fresh, but weather to a buff colour. Lamination is conspicuous in some of the coarser bands. Some beds of fine-grained green cherty mudstones occur. Fragmental plant-remains were the only fossils found. The strata dip south-east at 40°.

The age of the rocks is uncertain, but they are probably part of a widespread series occurring to the north-west around Bundarra and Ashford. These areas are marked as Kamilaroi and Lower Carboniferous on Professor Sir T. W. E. David's map of the Commonwealth of Australia, 1932. However, the Saumarez Creek beds and those around Bundarra are unlike Kamilaroi rocks elsewhere in the State and must be limited to the Carboniferous or Devonian suites. The writer found crinoid ossicles in gritty tuffs 32 miles from Armidale along the Bundarra road. These tuffs and the olive-green mudstones associated with them closely resemble the Burindi beds of the Hunter and Manning districts.

Lacking definite fossil evidence, the age of the beds can be put down, tentatively only, as Carboniferous.

(2) Conglomerates.

The writer's attention was drawn to an unusual conglomerate by the Rev. Norman McKie of Guyra. Lithologically, it resembles a conglomerate described by the writer from the lower portions of the Kullatine Series (Voisey, 1934), but,


GEOLOGICAL SKETCH MAP
OF THE COUNTRY SURROUNDING
ARMIDALE.
LEGEND
RECENT ALLUVIUM
TERTIARY BASALT
GRAVELS ETC.
CARBONIFEROUS ?
CONGLOMERATES
MUDSTONES ETC.
JASPERS AND QUARTZITES.
KAMILAROI GRANITE
APPROXIMATE HEIGHTS 2972'
GEOLOGICAL BOUNDARIES
ROADS
RAILWAY
PARISH BOUNDARIES
HILLS
Magnetic North
SCALE MILES
TILBUSTER SCHOOL
TILBUSTER CREEK
DUVAL CREEK
Parish of Duval
DUMARESQ SCHOOL
DUMARESQ CREEK
DUVAL VIEW SCHOOL
MITCHELLS KNOB
OAK KNOB
NEW ENGLAND UNIVERSITY COLLEGE
3370
3490'
REDMANS KNOB
Parish of Armidale
CITY OF ARMIDALE
3265
3400' TO BUNDARRA
3370
Parish of Butler
3320
TO REMPSEY
MT. THOMAS
MT. CAROLINE
HIGHWAY
3460
NEW ENGLAND
DUMARESQ CREEK
BALD KNOB
3420 KELLYS PLAINS
A
B
DUMARESQ CREEK
NEW ENGLAND UNIVERSITY COLLEGE
BASALT TERTIARY GRAVELS
TILBUSTER CREEK
4000'
3500'
3000'
GRANITE
CARBONIFEROUS ?
SECTION A-B

according to Professor Browne (verbal communication), it is similar to some of Devonian age which he had examined. The conglomerate contains a variety of pebbles, most being rounded and ranging up to a foot in diameter. The matrix is dark grey and apparently tuffaceous.

The conglomerate and associated subordinate tuffs outcrop along the New England Highway between the 9 and 12 mile-pegs going north from Armidale. They give way to mudstones and tuffs resembling those at Saumarez Creek at the Devil's Pinch immediately to the north.

What appears to be the same conglomerate outcrops around Dumaresq School. It has been contact metamorphosed and is associated with other altered rocks. This occurrence is a strong argument in favour of a correlation between the mudstones, tuffs and conglomerates described above and the jaspers and quartzites to be described in the next section.

(3) Jaspers and Quartzites.

Immediately to the east of Armidale are jaspers, quartzites and other hard siliceous rocks which form ridges trending north and south in conformity with the general strike of the country. They outcrop also between the New England University College and Dumaresq Creek and continue on both sides of the creek for some miles to the north-west.

The jaspers are red or pink in colour, very hard and highly jointed. They grade into white and greenish quartzites. White quartz veins interlace the rocks and line cavities in them.

Earlier maps, including Professor Sir T. W. E. David's map of the Commonwealth, show all the sedimentary and metamorphic rocks around Armidale as Silurian, together with the phyllites, slates, etc., occurring further to the east. This procedure is not supported by field evidence, which suggests that the beds are much younger and owe their extreme alteration to contact metamorphism for which granite which surrounds the area is responsible. No slates or phyllites were found within the parishes mapped.

Tertiary.

White quartz gravels and ferruginous sandstones outcrop around the margins of the basalt in a number of places. They represent stream deposits laid down during Tertiary and perhaps Mesozoic times. Grey billy is not uncommon and was found in the following localities: (*a*) Portion 52, Parish of Armidale, about 2½ miles south of Armidale, (*b*) near Duval View public school, (*c*) near Bald Knob beside the old Walcha Road in Portion 550, Parish of Armidale.

Dr. G. D. Osborne (1929) found leaves and other plant remains in ferruginous rocks at Armidale in the Tertiary sediments. One piece of ironstone contained what appeared to be an insect's wing.

The deposits are discontinuous and the basalt often is found resting directly upon the Upper Palaeozoic rocks. They do not appear to be very thick, but reach approximately 30 feet in portion 111, Parish of Butler, near the bridge over Saumarez Creek on the Armidale–Bundarra road, and may exceed this thickness somewhat in other localities.

Recent.

Alluvium composes the flats on each side of Dumaresq Creek. The soil is black in colour owing to the disintegration of basalt which caps the adjacent hills. Red soil, also derived from the basalt, covers many hillsides, obscuring the Tertiary sediments but frequently found to contain pebbles shed from them. This

soil covering prevents, in many places, the accurate determination of boundaries between the various rocks.

Igneous Rocks.

Kamilaroi Granite.

On the accompanying map granite is shown around Tilbuster and it outcrops outside the limits of the map, about ten miles south of Armidale, approximately the same distance to the east and twelve miles or less to the west. It would appear that it lies beneath Armidale at no great depth. The rock at Tilbuster appears to be identical with the "Porphyritic Granite" of Andrews (1903).

As many of the New England granites are intrusive into Kamilaroi rocks they are regarded as being late Kamilaroi in age.

Tertiary Basalt.

It is believed that a continuous sheet of basalt once covered the whole of the area under discussion. Erosion has revealed the underlying rocks and the basalt now occurs as cappings on the hills. The base of the basalt stands at present between 3,320 and 3,460 feet above sea-level. The slight differences in level may be attributed to the inequalities of the surface over which it flowed.

A thickness of at least 200 feet of rock is demonstrated in the district, but this was certainly much greater before the country was worn down to its present state.

The lava was responsible for the cementation of some of the sediments lying on the surface of the ground when it was poured out. This has produced the rock known as grey billy.

Physiography.

The Armidale District lies just eastward of the Main Divide and is drained by Dumaresq, Tilbuster and Saumarez Creeks, whose waters eventually reach the Macleay River. The city itself lies in the valley of Dumaresq Creek. The railway station is 3,265 feet above sea-level and adjacent hills attain 3,600 feet. Mount Duval, an imposing table-topped feature to the north, is over 4,000 feet.

The mature streams are commencing to become rejuvenated as a result of uplift and some miles downstream near Hillgrove their waters fall into a gorge more than 2,000 feet below the plateau level.

Saumarez Creek to the west has not been influenced yet by the uplift, and remains in its mature state, but Dumaresq and Tilbuster Creeks are cutting down into the hard siliceous rocks and consequently steepening the sides of their valleys and reducing the widths of their flood-plains.

Dumaresq Creek has been held up by a bar of jasper and quartzite a few miles east of Armidale and has formed a wider alluvial plain upstream. It is upon this that part of the city is built.

It is noteworthy that the streams tend to widen their valleys at the stage when they have cut down as far as the hard rocks below the basalt. Down-cutting further is difficult, while undercutting of the basalt is easy because of the underlying, poorly-consolidated gravel wash. This action is well demonstrated at Kelly's Plains.

A number of conspicuous "knobs" rise above the general level of the basalt to the extent of a hundred feet or more. These are Mitchell's Knob, Oak Knob, Redman's Knob, Bald Knob, Mount Thomas and Mount Caroline. Some may indicate centres of eruption, but this was not proved.

Geological History.

Conglomerates, tuffs, sandstones and mudstones were laid down, probably during Carboniferous times, accompanied by frequent volcanic eruptions. The sediments were folded and invaded by granites at the close of Kamilaroi times and were converted in part into jaspers and quartzites.

A long period of erosion followed, and gravels and sands were spread out over the land surface. During Tertiary times volcanic eruptions took place and lava flowed over the country, interrupting the drainage, filling up river valleys, and accumulating to form a thickness of many hundreds of feet.

After a further period of erosion the streams cut through the basalt—a process which was accentuated by uplift. Rejuvenation of the coastal streams is affecting the creeks in the Armidale district and they are gradually becoming entrenched in the older rocks.

Conclusion.

An attempt has been made to describe the geology of a comparatively small area around Armidale. Even in this there are several points which could not be determined definitely, the principal one being the age of the so-called Carboniferous rocks. Many other problems in the adjacent districts demand attention, but intrusive granite and the overlying sheets of basalt so interrupt the sequence that correlation between beds is very difficult and often impossible.

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ABSTRACT OF PROCEEDINGS.

ORDINARY MONTHLY MEETING.

30th March, 1938.

Mr. T. C. Roughley, B.Sc., F.R.Z.S., President, in the Chair.

The Donations and Exchanges received since the previous Monthly Meeting (24th November, 1937), amounting to 49 Volumes, 450 Parts or Numbers, 25 Bulletins, 11 Reports and 17 Pamphlets, received from 168 Societies and Institutions and 1 private donor, were laid upon the table.

PAPERS READ.

1. Revision of Australian Lepidoptera. Oecophoridae. vii. By A. Jefferis Turner, M.D., F.R.E.S.

2. The Ecology of the Central Coastal Area of New South Wales. ii. Plant Succession on the Hawkesbury Sandstone. By Ilma M. Pidgeon, M.Sc., Linnean Macleay Fellow of the Society in Botany.

ORDINARY MONTHLY MEETING

27th April, 1938.

Mr. T. C. Roughley, B.Sc., F.R.Z.S., President, in the Chair.

Professor Eric Ashby, Sydney University; Dr. Dorothy Hill, Brisbane, Queensland; Miss E. F. Lawrence, Mittagong, N.S.W.; Mr. L. D. Pryor, Canberra, F.C.T.; and Mr. A. L. Tonnoir, Canberra, F.C.T., were elected Ordinary Members of the Society.

The Chairman announced that the Council had elected Professor W. J. Dakin, Dr. W. L. Waterhouse, Mr. C. A. Sussmilch, and Mr. E. C. Andrews to be Vice-Presidents for the Session 1938–39.

The Chairman also announced that the Council had elected Dr. G. A. Waterhouse to be Honorary Treasurer for the Session 1938–39.

The Donations and Exchanges received since the previous Monthly Meeting (30th March, 1938), amounting to 27 Volumes, 176 Parts or Numbers, 7 Bulletins, 4 Reports and 4 Pamphlets, received from 91 Societies and Institutions, were laid upon the table.

PAPERS READ.

1. Miscellaneous Notes on Australian Diptera. iv. The Genus *Odontomyia* (Stratiomyiidae). By G. H. Hardy.

2. Descriptions of Four New Species and Two Varieties of Eucalypts. By W. F. Blakely, Rev. E. N. McKie, B.A., and H. Steedman.

3. A New Termitophilous Phorid (Diptera). By Mary E. Fuller, B.Sc., and D. J. Lee, B.Sc.

4. A Preliminary Investigation of the Natural History of the Tiger Flathead (*Neoplatycephalus macrodon*) on the South-eastern Australian Coast. ii. Feeding Habits; Breeding Habits. By A. N. Colefax, B.Sc.

NOTES AND EXHIBITS.

Mr. W. F. Blakely exhibited specimens of the following Eucalypts.—(1) *E. umbellata* (Gaertner) Domin, var. *glaucina* Blakely, from Mt. Jellore; Bringelly; Douglas Park; Paterson River; Sugar Loaf Creek, Dungog; Fosterton and Lower Monkerai, being an extension of its range in New South Wales. Also specimens from cultivated plants from Cape Colony; Santa Monica, California; and Uruguay, South America, which in no way differ from the type.—(2) x *E. brevirostris* Blakely; near Murray Hill, four miles up stream from the junction of Paddy's and Cotter Rivers, L. Pryor, 11/1937; new for New South Wales.—(3) *E. Kybeanensis* Maiden and Cambage. "Up to 15 feet high, Geehi River, at 4,000 feet elevation, also at 5,000 to 5,300 feet", Gilby, 2/1932. "Very common south-east of Mt. Useful, East Victoria at 4,200–4,500 feet." A Horne, 1/1938. First record for Victoria.—(4) *E. pauciflora* Sieb., var. *cylindrocarpa* Blakely and McKie. Buffalo Mountains, Victoria, near the Chalet. Mrs. G. Pring, 4/1938; new for Victoria. Golden Gate Park, San Francisco, Alice Eastwood, 12/1919.

ORDINARY MONTHLY MEETING.

25th May, 1938.

Mr. T. C. Roughley, B.Sc., F.R.Z.S., President, in the Chair.

Mr. C. K. Ingram, Armidale, N.S.W.; Dr. M. R. Jacobs, Canberra, F.C.T.; Dr. H. L. Kesteven, Strathfield; and Dr. D. Miller, Nelson, New Zealand, were elected Ordinary Members of the Society.

The President offered congratulations to Dr. W. L. Waterhouse on being selected as the Farrer Orator for this year and awarded the Farrer Oration Medal; to Dr. N. S. Noble on attaining the degree of Doctor of Science in Agriculture in the University of Sydney; and to Mr. D. Gilmour on being awarded the James King of Irrawang Scholarship.

The President called the attention of members to the fact that the next award of the Walter Burfitt Prize by the Royal Society of New South Wales would be made this year and that applications should be in the hands of the Hon. Secretaries of the Royal Society not later than 31st August next.

The Donations and Exchanges received since the previous Monthly Meeting (27th April, 1938), amounting to 27 Volumes, 102 Parts or Numbers, 6 Bulletins, 5 Reports and 10 Pamphlets, received from 73 Societies and Institutions and 2 private donors, were laid upon the table.

PAPERS READ.

1. Studies on the Pituitary Body. i. The Phyletic Occurrence of Pituicytes with a Discussion of the Evidence for their Secretory Nature. By M. Griffiths, B.Sc.

2. Studies on the Pituitary Body. ii. Observations on the Pituitary in Dipnoi and Speculations concerning the Evolution of the Pituitary. By M. Griffiths, B.Sc.

3. Notes on *Trichopsidea oestracea* (Nemestrinidae) and *Cyrtomorpha flaviscutellaris* (Bombyliidae)—two Dipterous Enemies of Grasshoppers. By Mary E. Fuller, B.Sc.

4. A List of the Insect Ectoparasites recorded from Australian Birds and Mammals. By G. B. Thompson and N. J. B. Plomley, B.Sc.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited (i) a live plant of *Callitris columellaris* raised from seed obtained from Brunswick Heads in February, 1934; also a plant raised from

seed obtained from trees grown in the grounds of the Gladesville Mental Hospital. Photographic illustrations of the latter were published in the *Sydney Morning Herald*, 12th September, 1933, and a suggestion was made that the plants were probably the same as the "Northern Rivers Cypress Pine" (*Callitris columellaris*), but the habit of growth and the bluish-grey or sea-green colour of the Gladesville plants clearly show that the latter belong to a different species. A seedling plant raised from seed collected by the late Mr. A. H. S. Lucas in Tasmania from the "Oyster Bay Pine" (*Callitris cupressiformis* var. *tasmanica* (Benth.) Syn.—*Frenela cupressiformis* var. *tasmanica* Benth.). A typical plant of the "Port Jackson Pine" (*Callitris cupressiformis* Vent.) was exhibited for comparison. The latter has the same drooping habit as the "Oyster Bay Pine", but the branchlets are more compact and dense and of a pale-green colour, while those of the "Oyster Bay Pine" are sparse and are dark green. It is difficult to say to what species the trees grown in the grounds of the Mental Hospital, Gladesville, should be assigned, as the matured trees are dark green and of a columnar habit, the branchlets being more or less clustered or fastigiate.

Mr. Cheel also exhibited (ii) specimens of (*a*) a "Cudweed" (*Gnaphalium* sp.) (probably a form of *G. spicatum*) which is becoming a serious pest in lawns because of its perennial duration, and (*b*) *Peganum harmala* L., a native of the Mediterranean Region, which was collected in the Young district in December, 1933, where it has apparently become naturalized.—(iii) Leaves, flowers and fruits of *Davidsonia pruinosa* and *D. jerseyana*, taken from plants cultivated at Ashfield, were shown to note the distinctive characters of the two species.

Mr. F. H. Taylor exhibited specimens of a fly, *Hermetia laglaizei* Bigot, Family Stratiomyiidae, from Wewak, Territory of New Guinea. This fly resembles a wasp in habit, flight and the noise it makes.

ORDINARY MONTHLY MEETING.

29th JUNE, 1938.

Mr. T. C. Roughley, B.Sc., F.R.Z.S., President, in the Chair.

The President referred to the deaths of Mr. Edward Meyrick, B.A., F.R.S., F.Z.S., an authority on Microlepidoptera, who had been a Corresponding Member of the Society since 1902, and Miss Sarah Hynes, B.A., M.B.E., who became an Associate Member in 1892 and an Ordinary Member in 1909 when women were admitted to full membership.

The Donations and Exchanges received since the previous Monthly Meeting (25th May, 1938), amounting to 24 Volumes, 181 Parts or Numbers, 5 Bulletins, 2 Reports and 8 Pamphlets, received from 83 Societies and Institutions and 1 private donor, were laid upon the table.

PAPERS READ.

1. A New *Sarcochilus* (Orchidaceae) from the Dorrigo. By Rev. H. M. R. Rupp, B.A.

2. On the Taxonomy of *Helicobia australis* (Sarcophaginae), a Dipterous Insect associated with Grasshoppers. By A. L. Tonnoir.

3. On the Biology and Early Stages of *Helicobia australis* (Sarcophaginae), a Dipterous Insect associated with Grasshoppers. By Mary E. Fuller, B.Sc.

4. The Ecology of the Upper Williams River and Barrington Tops Districts. ii. The Rain-Forest Formations. By Lilian Fraser, D.Sc., and Joyce W. Vickery, M.Sc.

NOTES AND EXHIBITS.

Dr. C. Anderson exhibited casts of the skulls of *Meiolania oweni*, from the Pleistocene of Queensland, *Meiolania platyceps*, from a coral-sand formation of Lord Howe Island, and *Niolamia argentina*, from the Eocene of Patagonia. These are horned turtles belonging to the family Meiolaniidae, and their occurrence in South America and the Australasian region has been considered to support the view that in former times these two regions were connected by way of the Antarctic continent. Recently a new member of the family, *Crossochelys corniger*, has been described from the Eocene of Patagonia by Dr. G. G. Simpson, American Museum of Natural History, who places the family in the Sub-order Amphichelydia, which was characteristically Mesozoic and of wide occurrence in the northern hemisphere. He considers that the Meiolaniidae supply no evidence either for or against an Antarctic bridge connecting South America with Australia.

Miss E. C. Pope exhibited three roentgenograms of parts of the blood-vascular system of the Port Jackson Shark, *Heterodontus portusjacksoni* (Meyer). The shark was freshly killed for the experiment and the blood vessels were washed out with saline solution. A mixture of red lead and 5% formalin was then injected, under pressure, into the vessels. X-ray plates were then made on the following day. The first plate, a side view of the caudal region, showed this method at its best and every tiny vessel was clearly indicated, the vertebral bodies of the backbone were clearly visible and even the denticles of the skin appeared. The next two plates, one of a side view of the head and another of the dorsal view of the trunk region, were not so successful. The thickness of these regions and the amount of cartilage which had to be penetrated accounted for this fact. However, whole areas appeared like networks, so great was the number of vessels shown. The large venous spaces were clearly shown and this, in itself, was most important since it is almost impossible to define their outlines and extent by dissecting methods as they are so thin-walled and collapse easily.

Mr. Consett Davis exhibited a specimen of *Grylloblatta campodeiformis*, received recently from British Columbia. This insect belongs to the family Grylloblattidae, a small family confined to North America and Japan. It is remarkable both for its primitive structure and for the narrow and low temperature range within which it can develop. Its optimum temperature is 4°C., and this results in a low metabolic rate and a prolonged life-cycle of seven years.

ORDINARY MONTHLY MEETING.

27th JULY, 1938.

Mr. T. C. Roughley, B.Sc., F.R.Z.S., President, in the Chair.

The President offered congratulations to Mr. M. Griffiths, M.Sc., on having been awarded a Science Scholarship of the Royal Commissioners for the Exhibition of 1851.

The President announced that the proclamation protecting certain native plants and flowers has been extended for a further period of twelve months as from 1st July, 1938.

The President informed members that notification has been received of the intention of the Australian National Research Council to publish, at intervals of two months, a journal of general scientific information, to be known as "*The Australian Journal of Science*", the first number to be issued on 22nd August, 1938.

The President also announced that information has been received that arrangements have been made for the continuation of publication of "*Biological Abstracts*".

The Donations and Exchanges received since the previous Monthly Meeting (29th June, 1938), amounting to 9 Volumes, 156 Parts or Numbers, 2 Bulletins and 10 Pamphlets, received from 74 Societies and Institutions and 3 private donors, were laid upon the table.

PAPERS READ.

1. New Species and Records of Tachinidae (Diptera). By C. H. Curran. (*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

2. Upper Devonian Sediments at Mt. Lambie, N.S.W. By Ida A. Brown, D.Sc., and Germaine A. Joplin, B.Sc., Ph.D.

3. A Key to the Marine Algae of New South Wales. i. Chlorophyceae. By Valerie May, B.Sc.

4. An Albino-form of *Macrozamia spiralis* Miq. By Valerie May, B.Sc.

NOTES AND EXHIBITS.

Mr. R. H. Anderson exhibited: (i) Specimens and illustrations of *Oxalis lobata* Sims., a Chilian plant which has become naturalized in New South Wales. It has been reported as being a fairly difficult weed to eradicate in the Grenfell district and appears to be spreading. Owing to the very free production of bulbils in the surface soil, ordinary cultivation during the summer months only helps to spread the weed.—(ii) Specimens of *Carpesium cernuum* L., which has now been determined as a plant native to New South Wales. The distribution of this species is interesting as it is fairly common in Europe and Temperate Asia, and is regarded as one of the most common and variable Himalayan plants. In New South Wales it has been found in the Coopernook State Forest near Taree, Manning River, Richmond River and Casino districts. The species appears to be undoubtedly a native one, and cannot be regarded as a naturalized introduction. Mr. C. T. White, Government Botanist of Queensland, also indicates that he regards it as a native of that State, and the species is quoted in Bailey's *Queensland Flora* as "decidedly indigenous".

ORDINARY MONTHLY MEETING.

31st August, 1938.

Mr. E. Cheel in the Chair.

Messrs. W. J. Gibbs, B.Sc., Epping, and J. R. Kinghorn, C.M.Z.S., Australian Museum, Sydney, were elected Ordinary Members of the Society.

The Chairman drew the attention of members to the first number of the *Australian Journal of Science*, published by the Australian National Research Council.

The Chairman announced that the Sydney University Biological Society invited members to a symposium on "Parasitism", to be held in the Botany School, University of Sydney, on Wednesday, 21st September, 1938, at 8 p.m., the chief speakers being Mr. A. R. Woodhill, Mr. H. M. Gordon, Professor Harvey Sutton and Dr. R. J. Noble.

The Chairman referred to the Chemical Industries Exposition, arranged by the Australian Chemical Institute, which will be held at the Sydney Town Hall from 26th September to 30th September and will be open daily from 11 a.m. to 10 p.m.

The Donations and Exchanges received since the previous Monthly Meeting (27th July, 1938), amounting to 5 Volumes, 92 Parts or Numbers, 7 Bulletins, 6 Reports and 35 Pamphlets, received from 72 Societies and Institutions, were laid upon the table.

PAPERS READ.

1. Studies in Australian Embioptera. Part iii. Revision of the Genus *Metoligotoma*, with Descriptions of New Species, and other Notes on the Family Oligotomidae. By Consett Davis, M.Sc., Linnean Macleay Fellow of the Society in Zoology.

2. Salinity Tolerance and pH Range of *Culex fatigans* Wied., with Notes on the Anal Papillae of Salt-water Mosquitoes. By A. R. Woodhill, B.Sc.Agr.

3. Description of Three New Species of *Stigmodera* (Buprestidae). By C. Deuquet, B.Com.

4. Fishes from Nauru, Gilbert Islands, Oceania. By G. P. Whitley, F.R.Z.S., and A. N. Colefax, B.Sc.

NOTES AND EXHIBITS.

Mr. E. Cheel exhibited some cultivated forms of the New Zealand "Manuka", *Leptospermum scoparium* Forster, together with some forms or subspecies of the Australian "Tea-tree" listed by Bentham and other Australian botanists as *L. scoparium* for comparison; also a specimen of the "Australian Rosemary", *Westringia fruticosa* (Willdenow) Druce, listed in Australian botanical literature under the name *Westringia rosmariniformis* Sm. The latter was propagated by cuttings, and roots freely when in sharp sand.

ORDINARY MONTHLY MEETING.

28th September, 1938.

Mr. T. C. Roughley, B.Sc., F.R.Z.S., President, in the Chair.

The President announced that the Council is prepared to receive applications for four Linnean Macleay Fellowships tenable for one year from 1st March, 1939, from qualified candidates. Applications should be lodged with the Secretary, who will afford all necessary information to intending candidates, not later than Wednesday, 2nd November, 1938.

The President referred to the sudden death, on Saturday, 24th September, of Miss Mary E. Fuller, B.Sc., who had been a member of the Society since 1930.

The Donations and Exchanges received since the previous Monthly Meeting (31st August, 1938), amounting to 23 Volumes, 98 Parts or Numbers, 9 Bulletins, 1 Report and 8 Pamphlets, received from 64 Societies and Institutions and 3 private donors, were laid upon the table.

PAPERS READ.

1. Notes on Australian Diptera. xxxvii. By J. R. Malloch. (*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

2. The Anatomy of *Heterodontus portusjacksoni* (Meyer, 1793). i. The Nervous System. By Elizabeth C. Pope, B.Sc., Linnean Macleay Fellow of the Society in Zoology.

3. The Upper Palaeozoic Rocks of Tasmania. By A. H. Voisey, M.Sc., Linnean Macleay Fellow of the Society in Geology.

NOTES AND EXHIBITS.

Mr. T. C. Roughley exhibited specimens of shrimp-like Euphausid crustaceans, *Nyctiphanes australis*, which averaged about five-eighths of an inch in length. These crustaceans entered Watson's Bay, Port Jackson, on the morning of 17th

September in great swarms, accompanied by shoals of small fish which were feeding on them voraciously, while larger fish and gulls were taking toll of the smaller fish.

At night great quantities of the crustacea swarmed along the eastern shore of Parsley Bay over a length of about fifty yards and a width of two or three yards, forming a luminous area which was visible for two or three hundred yards. The receding tide had left myriads of them stranded on the sand and rocks, and as one walked over them they glowed with a beautiful pale-blue luminescence. This luminescence is under the control of the animal when alive and may persist for long after it is dead. The organs responsible for it are situated on the outer margin of each eye, on the bases of the second and seventh thoracic limbs, and on the ventral median line on the first four abdominal segments. They are lantern-like structures provided with a lens, reflector, and light-producing tissue.

ORDINARY MONTHLY MEETING.

26th October, 1938.

Mr. T. C. Roughley, B.Sc., F.R.Z.S., President, in the Chair.

The President reminded candidates for Linnean Macleay Fellowships, 1939–40, that Wednesday, 2nd November, 1938, is the last day for receiving applications.

The Donations and Exchanges received since the previous Monthly Meeting (28th September, 1938), amounting to 6 Volumes, 110 Parts or Numbers, 6 Bulletins and 4 Pamphlets, received from 53 Societies and Institutions, were laid upon the table.

PAPERS READ.

1. *Tepperella trilineata* Cam., a Wasp causing Galling on the Flower Buds of *Acacia decurrens*. By N. S. Noble, D.Sc.Agr., M.Sc., D.I.C.

2. Notes on the Terrestrial Ecology of the Five Islands. i. By Consett Davis, M.Sc., M. F. Day, B.Sc., and D. F. Waterhouse, B.Sc.

3. The Diptera of the Territory of New Guinea. vi. Family Stratiomyiidae. By Dr. Erwin Lindner. (*Communicated by Frank H. Taylor, F.R.E.S., F.Z.S.*)

NOTES AND EXHIBITS.

Mr. R. H. Anderson exhibited specimens and photographs of *Casuarina equisetifolia* var. *incana*, obtained from Port Macquarie. This represents the most southern locality of this fairly rare species and attention was drawn to the possibility of this tree for seaside planting as it is extremely resistant to the ill-effects of prolonged and high winds.

ORDINARY MONTHLY MEETING.

30th November, 1938.

Mr. T. C. Roughley, B.Sc., F.R.Z.S., President, in the Chair.

The President announced that the Council had reappointed Miss Elizabeth C. Pope, B.Sc., Mr. H. F. Consett Davis, M.Sc., Mr. A. H. Voisey, M.Sc., and Miss Ilma M. Pidgeon, M.Sc., to Linnean Macleay Fellowships in Zoology, Zoology, Geology and Botany respectively, for one year from 1st March, 1939.

The Donations and Exchanges received since the previous Monthly Meeting (26th October, 1938), amounting to 10 Volumes, 108 Parts or Numbers, 2 Bulletins, 1 Report and 12 Pamphlets, received from 57 Societies and Institutions and 3 private donors, were laid upon the table.

PAPERS READ.

1. Comparative Anatomy of Leaves from Species in two Habitats around Sydney. By Gladys Carey, M.Sc.

2. The Geology of the Armidale District. By A. H. Voisey, M.Sc., Linnean Macleay Fellow of the Society in Geology.

3. The Upper Palaeozoic Rocks in the Neighbourhood of Taree, N.S.W. By A. H. Voisey, M.Sc., Linnean Macleay Fellow of the Society in Geology.

4. Papuan Diptera. i. Family Diopsidae. By J. R. Malloch. (*Communicated by F. H. Taylor, F.R.E.S., F.Z.S.*)

5. Australian Hesperiidae. viii. Descriptions of new Forms. By G. A. Waterhouse, D.Sc., B.E., F.R.E.S.

NOTES AND EXHIBITS.

Dr. G. A. Waterhouse recorded that pupae of *Hesperilla ornata* Hew. had been found at Springbrook, S. Queensland, 3,200 feet, by Miss May Smales. These have emerged and specimens were given him by Mr. T. H. Guthrie.

Mr. E. Cheel exhibited seeds of *Acacia leprosa* Sieb., collected at "Wattle-Ridge" near Hill Top (Picton–Mittagong Branch Line), in January, 1921. Twenty-five seeds were sown in sandy loam on 29th October, five of which germinated and pushed the cotyledons through the soil, but only one has succeeded in developing the first pinnate leaf with two pairs of leaflets.

DONATIONS AND EXCHANGES.

Received during the period 28th October, 1937, to 26th October, 1938.

(From the respective Societies, etc., unless otherwise mentioned.)

ABERYSTWYTH.—*Welsh Plant Breeding Station, University College of Wales.* "The Welsh Journal of Agriculture", xiv (1938).

ACCRA.—*Geological Survey Department, Gold Coast Colony.* Report for the Financial Year 1936-37 (1937).

ADELAIDE.—*Department of Mines: Geological Survey of South Australia.* Annual Report of the Director of Mines and Government Geologist for 1936 (1937); Bulletin No. 17 (1938); Mining Review for the Half-years ended 30th June, 1937 (No. 66) (1937) and 31st December, 1937 (No. 67) (1938).—*Field Naturalists' Section of the Royal Society of South Australia and South Australian Aquarium Society.* "South Australian Naturalist", xviii, 1-4 (1937-1938); xix, 1 (1938).—*Public Library, Museum and Art Gallery of South Australia.* 53rd Annual Report of the Board of Governors, 1936-37 (1937); Records of the South Australian Museum, vi, 1 (1937).—*Royal Society of South Australia.* Transactions and Proceedings, lxi (1937); lxii, 1 (1938).—*South Australian Ornithological Association.* "The South Australian Ornithologist", xiv, 4-7 (1937-1938).—*University of Adelaide.* "The Australian Journal of Experimental Biology and Medical Science", xv, 4 (T.p. & c.) (1937); xvi, 1-3 (1938).—*Woods and Forests Department.* Annual Report for the Year ended 30th June, 1937 (1938).

ALBANY.—*New York State Library, University of the State of New York.* New York State Museum Bulletin, Nos. 311, 312 (1937); New York State Museum Handbook 17 (1937).

ALGER.—*Institut Pasteur d'Algerie.* Archives, xv, 3-4 (T.p. & c.) (1937); xvi, 1-2 (1938).—*Société d'Histoire Naturelle de l'Afrique du Nord.* Bulletin, xxviii, 4-9 (T.p. & c.) (1937); xxix, 1-5 (1938).—*Station d'Aquiculture et de Pêche de Castiglione.* Bulletin, 1935, 1-2 (T.p. & c.) (1936-1937); 1936, 1 (1938).

AMSTERDAM.—*Koninklijke Akademie van Wetenschappen.* Proceedings of the Section of Sciences, xl, 1-10 (T.p. & c.) (1937); continued as Proceedings, xli, 1-5 (T.p. & c.) (1938); Verhandelingen Afdeeling Natuurkunde, 2e Sectie, xxxvi, 1-5 (T.p. & c.) (1937); xxxvii, 1-4 (1938).—*Nederlandsche Entomologische Vereeniging.* Entomologische Berichten, ix, 216-218 (T.p. & c.) (1937); x, 219-221 (1938); Tijdschrift voor Entomologie, lxxx, 3-4 (T.p. & c.) (1937); lxxxi, 1-2 (1938).

ANN ARBOR.—*University of Michigan.* Contributions from the Laboratory of Vertebrate Genetics, No. 6 (1938); Contributions from the Museum of Palaeontology, v, 7-9 (1937); Miscellaneous Publications of the Museum of Zoology, Nos. 35-39 (1937-1938); Occasional Papers of the Museum of Zoology, Nos. 349-377 (1937-1938); Papers of the Michigan Academy of Science, Arts and Letters, xxii, 1936 (1937); xxiii, 1937 (1938).

ATHENS.—*Zoological Institute and Museum, University of Athens.* Acta, i, 11-12 (T.p. & c.) (1937); ii, 1-2 (1938).

AUCKLAND.—*Auckland Institute and Museum.* Records, ii, 2 (1937).

BALTIMORE.—*Johns Hopkins University.* Bulletin of the Johns Hopkins Hospital, lxi, 4-6 (T.p. & c.) (1937); lxii, 1-6 (T.p. & c.) (1938); lxiii, 1-3 (1938).—*Maryland Geological Survey.* General Reports, xiii (1937).

BANDOENG.—*Dienst van den Mijnbouw in Nederlandsch-Indie.* Bulletin of the Netherlands Indies Volcanological Survey, Nos. 80-83 (1937-1938).

BASEL.—*Naturforschende Gesellschaft.* Verhandlungen, xlviii, 1936-37 (1937).

BATAVIA.—*Departement van Economische Zaken.* Bulletin du Jardin Botanique, Serie iii, xiv, 3-4 (T.p. & c.) (1937); xv, 2-3 (1937-1938); "Treubia", xvi, 2-3 (1937-1938).—*Koninklijke Natuurkundige Vereeniging in Nederlandsch-Indie.* Natuurkundig Tijdschrift voor Nederlandsch-Indie, xcvii, 8 (T.p. & c.) (1937); xcviii, 1-4 (1938).—*Natuurwetenschappelijke Raad voor Nederlandsch-Indie te Batavia (Netherlands India Science Council).* Publication, No. 11 (September, 1937).

BERGEN.—*Bergens Museum.* Arbok, 1937, 1-2 (T.p. & c.) (1937); Arsberetning, 1936-37 (1937).

BERKELEY.—*University of California.* Bulletin of the Department of Geological Sciences, xxiv, 8-10 (1937-1938); Publications, Botany, xviii, 5; xix, 6 (1937); Entomology, vi, 14-16 (T.p. & c.); vii, 1-2 (1937); Physiology, viii, 12-13 (1937); Zoology, xli, 17-27 (T.p. & c.) (1937-1938); xlii, 1-5 (1937-1938); xliii, 1-8 (1938); Publications of the University of California at Los Angeles in Biological Sciences, i, 9 (1938).

BERLIN.—*Deutsch-Auslandischer Buchtausch.* "Flora", Neue Folge, xxxii, 2-4 (T.p. & c.) (1938).—*Zoologische Museum.* Mitteilungen, xxii, 2, Sonderheft to Heft 2 (T.p. & c.) (1937); xxiii, 1 (1938).

BERLIN-DAHLEM.—*Botanisch Garten und Museum.* Notizblatt, xiii, 120 (T.p. & c.) (1937); xiv, 121-122 (1938).—*Deutsches Entomologisches Institut.* Arbeiten uber morphologische und taxonomische Entomologie aus Berlin-Dahlem, iv, 3-4 (T.p. & c.) (1937); v, 1-3 (1938); Arbeiten uber physiologische und angewandte Entomologie aus Berlin-Dahlem, iv, 3-4 (T.p. & c.) (1937); v, 1-2 (1938); Entomologische Beihefte aus Berlin-Dahlem, v (1938).

BERN.—*Naturforschende Gesellschaft.* Mitteilungen a.d. Jahre 1937 (1938).—*Schweizerische Naturforschende Gesellschaft.* Verhandlungen, 118. Jahresversammlung, 1937 (1937).

BIRMINGHAM.—*Birmingham Natural History and Philosophical Society.* List of Members, 1937 and 1938 and Annual Report for 1936 and 1937; Proceedings, xvi, 8 (1938).

BLOEMFONTEIN.—*Nasionale Museum.* Argeologiese Navorsing, i, 8 (1938); Soologiese Navorsing, i, 7 (1937).

BOLOGNA.—*Istituto di Entomologia della R. Universita di Bologna.* Bollettino, ix (1936-1937).

BOMBAY.—*Bombay Natural History Society.* Journal, xxxix, 4 (1937); xl, 1 (General Index of Subjects and Authors for Vols. xxxi-xxxvi) (1938).—*Haffkine Institute.* Report for the Year 1936 (1937).

BONN.—*Naturhistorischer Verein der Rheinlande und Westfalens.* "Decheniana", xcv (A and B)–xcvi (A and B) (1937).

BOSTON.—*American Academy of Arts and Sciences.* Proceedings, lxxii, 1-10 (T.p. & c.) (1937-1938).

BRISBANE.—*Department of Agriculture.* Queensland Agricultural Journal, xlviii, 5-6 (T.p. & c.) (1937); xlix, 1-6 (T.p. & c.); l, 1-3 (1938).—*Department of Mines: Geological Survey of Queensland.* "Queensland Government Mining Journal", xxxviii, Oct.-Dec., 1937 (T.p. & c.) (1937); xxxix, Jan.-Aug., 1938 (1938).—*Great Barrier Reef Committee.* Reports, iv, 3 (1938).—*Queensland Naturalists' Club and Nature-Lovers' League.* "The Queensland Naturalist", x, 4-6 (1938).—*Royal Society of Queensland.* Proceedings, xlviii, 1936 (1937).

BRNO.—*Prirodovedecka Fakulta, Masarykovy University.* Spisy (Publications) (Botanical only), Cis. 238, 242 (1937); "Mohelno", 1a, 1937 (1937).

BROOKLYN.—*Brooklyn Botanic Garden.* "Genetics", xxii, 6 (T.p. & c.) (1937); xxiii, 1-5 (1938).

BRUSSELS.—*Académie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique.* 104me Annuaire, 1938 (1938); Bulletin de la Classe des Sciences, 5me Série, xxiii, 6-12 (T.p. & c.) (1937); xxiv, 1-2 (1938).—*Musée Royal d'Histoire Naturelle de Belgique.* Bulletin, xii, 34-45 (T.p. & c.) (1936); xiii, 1-46 (T.p. & c.) (1937); Mémoires, Nos. 79-81 (1936-1937); Mémoires, 2me Série, Fasc. 8-12 (1936-1937); Mémoires, Hors Série (Résultats Scientifiques du Voyage aux Indes Orientales Néerlandaises), ii, 18 (1937); v, 4 (T.p. & c.) (1937).—*Société Entomologique de Belgique.* Bulletin and Annales, lxxvii, 6-12 (T.p. & c.) (1937); lxxviii, 1-2 (1938).—*Société Royale de Botanique de Belgique.* Bulletin, lxx, 1 (1937).—*Société Royale Zoologique de Belgique.* Annales, lxvii, 1936 (1937).

BUDAPEST.—*Hungarian National Museum: Zoological Department.* Annales Historico-Naturales, xxxi, 1937-38 (1938).

BUENOS AIRES.—*Ministerio de Agricultura de la Nacion.* Memoria de la Comision Central de Investigaciones sobre la Langosta. Correspondiente al Ano (1935) (1937).—*Sociedad Entomologica Argentina.* Revista, ix (1937).

BUITENZORG.—*Nederlandsch-Indische Entomologische Vereeniging.* Entomologische Mededeelingen van Nederlandsch-Indie, iii, 4 (1937); iv, 1-2 (1938).

CAEN.—*Société Linnéenne de Normandie.* Bulletin, 8e Série, ix, 1936 (1937); x, 1937 (1938); Mémoires, Nouvelle Série, Section Zoologique, i, 2 (1937).

CAIRNS.—*North Queensland Naturalists' Club.* "North Queensland Naturalist", vi, 52-55 (all with Supplements) (1937-1938).

CALCUTTA.—*Geological Survey of India.* Memoirs, lxxii, 1 (1938); Memoirs, Palaeontologia Indica, N.S. xxii, 5 (1937); Records, lxxi, 4 (T.p. & c.) (1937); lxxii, 2-3 (1937); lxxiii, 1 (1938).—*Zoological Survey of India.* Catalogue of Indian Insects, Part 23 (1938); Records of the Indian Museum, xxxix, 3-4 (1937).

CAMBRIDGE.—*Cambridge Philosophical Society.* Biological Reviews, xii, 4 (T.p. & c.) (1937); xiii, 1-3 (1938).—*University of Cambridge.* Abstracts of Dissertations approved for the Ph.D., M.Sc., and M.Litt. Degrees during the Academical Year 1936-37 (1937).

CAMBRIDGE, Mass.—*Museum of Comparative Zoology at Harvard College.* Annual Report of the Director for 1936-37 (1937); Bulletin, lxvi, 3-4 (T.p. & c.) (1937-1938); lxxix, 8-9 (T.p. & c.) (1937); lxxx, 9-14 (T.p. & c.) (1937-1938); lxxxi, 4 (1937); lxxxii, 2 (1937).

CANBERRA.—*Commonwealth Bureau of Census and Statistics.* Official Year Book, No. 30, 1937 (1937).—*Council for Scientific and Industrial Research: Divisions of Economic Entomology and Plant Industry.* Contributions (Economic Entomology), Nos. 110-127 (1937-1938); (Plant Industry), Nos. 77-100 (1937-1938).

CAPE TOWN.—*Royal Society of South Africa.* Transactions, xxv, 1-4 (T.p. & c.) (1937-1938); xxvi, 1-3 (1938).—*South African Museum.* Annals, xxxii, 3 (1937); xxxiv (complete) (1938); Report for Year ended 31st December, 1937 (1938).

CHERBOURG.—*Société Nationale des Sciences Naturelles et Mathématiques de Cherbourg.* Mémoires, xlii (1933-1936).

CHICAGO.—*Chicago Academy of Sciences.* Bulletin, v, 5 (1937); Program of Activities, vii, 2-3 (1936); viii, 1-3 (1937).—*Field Museum of Natural History.* Botany, Leaflet 21 (1937); Publications, Botanical Series, xiii, pt. vi, No. 2; xvi, 1-2 (Title page); xvii, 2-4; xviii, 1-2; xix, 1-2 (1937-1938); Geological Series, vi, 18-20 (1937-1938); vii, 3 (1937); Zoological Series, xx, 23-29 (1937-1938); xxiii (complete) (1938).

CHRISTCHURCH.—*Canterbury Museum.* Records, iv, 4 (1938).

CLUJ.—*Gradina Botanica.* Buletinul, xvii, 3-4, Appendix 1-2 (T.p. & c.) (1937-1938); Contributions Botaniques de Cluj, T.p. & c. for ii, 1929-1937 (1937).

COIMBRA.—*Universidade de Coimbra: Instituto Botanica.* Boletim da Sociedade Broteriana, Serie ii, xii (1937); *Museu Zoologico.* Memorias e Estudios, Serie i, No. 71, Fls. 10-14 (T.p. & c.), 89-92, 94-105 (1936-1937); "Vocabulario de têrmos gregos de uso frequente em Zoologia e Antropologia" by J. G. de Barros e Cunha (1937).

COLOMBO.—*Colombo Museum.* Spolia Zeylanica (Ceylon Journal of Science, Section B—Zoology and Geology), xx, 2-3 (1937); xxi, 1 (1938).

COLUMBUS.—*Ohio State University and Ohio Academy of Science.* "Ohio Journal of Science", xxxvii, 5-6 (T.p. & c.) (1937); xxxviii, 1-4 (1938).—*Ohio State University: Ohio Biological Survey.* Bulletin 34 (1938).

COPENHAGEN.—*Det Kongelige Danske Videnskabernes Selskab.* Biologiske Meddelelser, xiii, 11-13 (T.p. & c.) (1937); xiv, 1-2, 4 (1938); Mémoires, Section des Sciences, 9me Série, vii, 2-4 (1938).

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LIST OF MEMBERS, 1938.

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Plants in the rain-forest formations of the Upper Williams River and Barrington Tops districts (pp. 139-184);
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Parts I–II (Pages i–xliii; 1–80).

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CORRIGENDA.

Page 229, explanation of Figs. 1-4 should read

Figs. 1-4.—*Metoligotoma reducta* Davis.—1. Dorsal aspect of well-developed head-capsule, ♂ × 12; 2. Dorsal aspect of ♂ terminalia, × 25; 3. Process of left hemitergite of tenth abdominal segment viewed from above, with extremity raised to same level as base, × 30; 4. Ventral aspect of left cercus-basipodite, ♂, stippling to indicate degree of chitinization, adjacent structures indicated in outline to show relations, × 25.

Page 236, Figs. 31-37, for *ingens*, n. sp. read *ingens* Davis.

Page 251, line 38, for *M. collina*, read *M. collina collina*

(Issued 15th December, 1938.)

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1923	2 6	12 0	16 0	13 6	2 0
1924	2 0	13 6	12 6	10 0	2 0
1925	2 0	12 0	8 9	14 6	2 0
1926	2 0	13 6	9 6	15 0	2 0
1927	2 6	10 6	14 0	12 3	2 0

Year.	Part 1.	Part 2.	Part 3.	Part 4.	Part 5.	Part 6.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1928	2 0	8 6	8 9	10 0	9 0	2 0
1929	2 0	6 3	8 6	11 0	12 6	2 0
1930	2 0	10 0	8 9	8 6	16 3	2 0
1931	2 0	8 0	7 0	7 3	8 9	2 0

Year.	Parts 1–2.	Parts 3–4.	Parts 5–6.
	s. d.	s. d.	s. d.
1932 ..	6 6	9 6	8 6
1933 ..	8 0	11 9	8 6
1934 ..	6 6	8 6	10 9
1935 ..	7 9	10 3	11 3
1936 ..	6 6	7 0	9 9
1937 ..	6 0	9 3	8 9
1938 ..	6 3	11 6	9 9

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